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THE IMPACT ABRASION-HARDNESS OF CERTAIN MINERALS AND CERAMIC PRODUCTS*

By Lowell H. Milligan

Abstract

Impact abrasion was produced by an accurately controlled blast of "standard Ottawa quartz sand." The "abrasion-hardness" of various glasses, minerals, hotel chinaware, porcelains, abrasive, refractory, and miscellaneous materials was thus determined in comparison with plate glass which was chosen as a standard. A relationship between crystallographic orientation and abrasion-hardness was demonstrated in the case of feldspar and quartz crystals. A Brazilian quartz crystal was found to have trigonal and not hexagonal abrasion-hardness symmetry. The hardness of hotel chinaware and of porcelains tested ranged from 3.2 to 7, with the surface skin on one sillimanite-type porcelain giving the high value of 34 (plate-glass standard = 1.00). Crystalline α-alumina gave a value of about 40, and silicon carbide about 400. Experiments with abrading grains other than quartz sand showed that corresponding hardness values for such hard materials as crystalline α-alumina and silicon carbide come much closer together when hard artificial abrasive grains are used for the blasting.

I. Introduction

The hardness of a material is a function of the method used to determine it. Thus Sosman[1] says, "The word 'hardness' is used for a number of different ideas, most of which are not very exactly definable in terms of the true physical constants of a substance. . . . Hardness is thus a quality which can be defined only by exact specifications of the manner of testing; hence, there are as many kinds of hardness as there are ways of testing it."

The hardness determined in this paper is impact abrasion-hardness, that is, the resistance to impact abrasion produced by an accurately controlled blast of "standard Ottawa sand" (about 24- to 30-mesh, round-grain silica quartz sand) at relatively high pressure.[2] The methods of use and interpretation of results have been worked out in the course of the present investigation.

The impact abrasion-hardness value given by the present method is relative to the rate of wear of a standard sample of plate glass under the same test conditions. An abrasion-hardness value of 1.00 is arbitrarily assigned to the plate glass. An abrasion-hardness value of 2.00 for a material shows that it is twice as hard as plate glass, and means that twice as long a time or twice as much abrasion in the test is required to wear away a given amount of this material as is required for the plate-glass standard.

In operation of the machine, the open end of the nozzle from which the sandblast issues is a standard distance away from the specimen. A lever is pulled (Fig. 1), starting the sandblast in operation at a predetermined air pressure. Each blast contains a definite volume of sand (about 48 cubic centimeters), and six to ten seconds are required for this to pass through the nozzle. The depth of hole produced in the specimen is obtained by reading an indicator dial that is a part of the machine. Any number of successive blasts can be made in the same hole.

When a homogeneous material is studied by means of successive sandblasts applied at the same spot, the increase in depth of the hole per blast becomes less as the hole becomes deeper. Comparisons of two materials, such as a material whose abrasion-hardness is to be determined and plate glass, are therefore calculated at the same hole depth, the ratios being taken between the numbers of blasts required to produce this hole depth in the two specimens with machine conditions remaining constant.

For convenience, a standard "penetration curve" for plate glass is established, in which the total depth of penetration is plotted on log-log cross-section paper against the number of blasts used to obtain it. The accuracy of the machine is such that this curve can be reproduced with precision over considerable periods of time.

The procedure for obtaining the abrasion-hardness of an unknown material is to make successive penetrations on it in the same hole, taking a reading of the hole depth after each blast. These

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (Refractories Division). Received February 11, 1936.

[1] R. B. Sosman, The Properties of Silica, p. 490. The Chemical Catalog Co., 1927.

[2] The tests were made in a machine designed and manufactured by the Carl Zeiss Co., Jena, Germany.

results are then plotted on log-log cross-section paper in a similar manner to that used for the standard plate-glass curve. The abrasion-hardness of the specimen can be calculated at any desired depth covered by the curve by taking the simple ratio between the number of blasts required to produce this hole depth in the specimen, compared to the number of blasts required to produce the same hole depth according to the standard penetration curve for plate glass. Log-log cross-section paper is used in preference to ordinary cross-section paper because the shape of the curve plotted on the log-log paper more nearly approaches a straight line, and it is therefore easier to draw an accurate curve through the experimental points.

II. Results

Abrasion-hardness results obtained for different materials are listed in Table I.

III. Discussion of Results

Most of the glasses that have been experimented with have been found to have an impact abrasion-hardness between 1 and 2. Pyrex-brand glass is

TABLE I

IMPACT ABRASION-HARDNESS VALUES USING "STANDARD SILICA SAND"

		Impact abrasion-hardness (using "standard silica sand")
Glasses		
Plate glass		1.00
Window glass		1.0–1.1
Pyrex-brand glass		3.0
Clear fused silica (General Electric Co.)		3.5–3.8
Minerals		
White marble (fine crystalline)		0.70
Feldspar (salmon colored from Buckingham, Quebec, Can.)	001 plane	1.6
	010 "	2.6
Feldspar (Topsham, Me.)	001 plane	1.4
	100 "	2.3
Feldspar (S. D.)	001 plane	1.4
	010 "	2.0
	100 "	2.7
Quartz (data on a Brazilian right-handed quartz crystal, see Fig. 2)	Plus trigonal prism faces	5.1
	Minus " " "	4.5
	Plus rhombohedron "	5.7
	Artificial basal plane	4.9
	Cleavage face parallel to minus rhombohedron	4.3
Quartz crystal of unknown source, artificial basal plane		5.0
Maine vein quartz (small crystals miscellaneously oriented)		5.4
South African corundum (data on a greenish brown hexagonal crystal)	Prism face	9.8
	" "	12.0
	Basal plane	14.0
Hotel chinaware and porcelains		
Hotel chinaware body (Onondaga Pottery Co., Syracuse, N. Y.)		3.2
Electrical insulator porcelain body (Jeffery-Dewitt Insulator Co., Kenova, W. Va.)		3.3
Spark-plug and chemical-porcelain bodies (sillimanite type) (Champion Spark Plug Co., Detroit, Mich.) (data are for different mixtures and the higher figure in each case is for the surface skin)		5.5–4 7.0–5 11.0–6
Refractory porcelain body (sillimanite type) (Champion Spark Plug Co., Detroit, Mich.) (the extremely high figure is for the surface skin on unglazed ware)		34–7
Glaze on Champion porcelains seems to be about		4–5
Abrasive and refractory materials		
South African corundum (see under minerals above)		10–14
Alundum (crystalline α-alumina) about		40.0
Crystolon (silicon carbide) "		400.0
Electrically fused magnesia (Norton Co.)		1.5
" " mullite " "		5–7
Miscellaneous		
Silicon (J. T. Baker Chemical Co.)		2.7

markedly harder than this, with a value of 3, approaching the hardness of fused silica (3.5 to 3.8).

Of the minerals tested, marble was the softest, being much softer than plate glass. The three feldspar samples examined were found to be similar in hardness on corresponding crystal faces, but the different crystallographic directions gave different results. Thus an average value of 1.5 would apply to faces parallel to the 001 plane.

FIG. 1.—The Zeiss sandblast machine for impact abrasion-hardness testing.

This value is lower than those in other crystallographic directions and may be due to the perfect cleavage in this direction, which tends to split off flakes under the impact of the silica-sand grains. The abrasion-hardness is greatest on faces parallel to the 100 plane, to which both the cleavages of feldspar present an edge, and is about 2.5. Faces parallel to the 010 plane, along which there is a good but not perfect cleavage, have an intermediate hardness.

Crystal quartz is quite an interesting material for hardness studies, because it is one of the standards on Moh's scratch-hardness scale[3] and because the data in the literature are quite conflicting as to its hardness in different crystallographic directions. The writer's data show that by the present method quartz has an average abrasion-hardness of about 5.0. The detailed study of a right-handed Brazilian quartz crystal (see Fig. 2) showed that the abrasion-hardness of the prism faces was trigonal in symmetry and that adjacent or opposite faces were not alike. Thus, the prism faces associated with the plus rhombohedron faces (these were striated only very finely and faintly) gave hardness values from 4.95 to 5.40; whereas, the minus prism faces (coarsely and deeply striated) gave hardness values from 4.40 to 4.67.

The plus rhombohedron faces were found to be

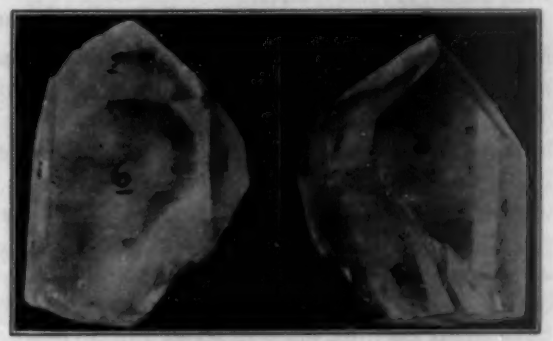

FIG. 2.—Brazilian quartz crystal; natural crystal faces, except for the cleavage face, No. 15, and the artificial basal plane made by grinding.

even harder than the corresponding prism faces and ranged from 5.32 to 6.17. The minus rhombohedron faces were too small to test, but an artificial plane (probably a cleavage plane, although the cleavage of quartz is only poorly defined) parallel to a minus rhombohedron face gave an abrasion-hardness of 4.26. An artificial basal plane ground on the crystal gave 4.9.

These results show that the plus rhombohedron faces were the hardest part of the crystal and indicate the minus rhombohedron faces to be the softest part of the crystal. The prism faces were intermediate in hardness, but those associated with the hard rhombohedron were harder than those associated with the soft rhombohedron. This type of variation in hardness seems to fit in

[3] A discussion of scratch hardness as well as of impact abrasion-hardness values for electrochemical products using No. 30 E-1 Alundum grain for blasting will be found in a paper by R. R. Ridgway, A. H. Ballard, and B. L. Bailey, "Hardness Values for Electrochemical Products," *Trans. Electrochem. Soc.*, **63**, 369 (1933); *Ceram. Abs.*, **12** [10–11] 386 (1933).

with the trigonal symmetry disclosed by other observations, such as the character of striations and of etch pits produced with hydrofluoric acid, but as far as the writer is aware, has not been discovered before. Variations of this type may explain some of the discrepancies in hardness data found in the literature, but attention should be called to the fact that the detailed information presented here is confined to data on one crystal only, and the writer does not know how other crystals or crystals from other localities would vary in hardness.

Fused quartz glass (vitreous silica) was found to be considerably softer than the crystal quartz, the average values being 3.4 for two samples of the General Electric Company product compared with 5.0 for crystal quartz.

Hotel chinaware[4] and insulator porcelain (high feldspar body)[5] were found to be about alike in abrasion-hardness, an average value being about 3.3. Spark-plug, chemical, and refractory porcelains of the sillimanite type[6] were found to be much harder, giving values from 4 to 6 for the interior part of cone 17 bodies (5.5 to 11.0 for the surface skin) and 7 for the interior part of a cone 32 body (34 for its surface skin). Even the glazes on these sillimanite-type porcelains seemed to have an abrasion-hardness of about 4 to 5.

The interior part of the sillimanite-type cone 32 porcelain body was thus found to be intermediate in hardness between quartz and a crystal of South African corundum that was studied and, furthermore, the hardness of the surface layer approached that of crystalline α-alumina.

The conditions attending the determination of the impact abrasion-hardness data on abrasive materials differ from most of the hardness data previously presented, in that the standard silica sand used for abrading is softer than the material being studied. This tends to over-emphasize the effect of softer components such as slag present in the abrasive material, but it does give a correct value for the abrasion resistance under the particular conditions of test. A greenish brown crystal of South African corundum had an abrasion-hardness of 10 to 14; Alundum (crystalline α-alumina) gave from 22 to 42, depending on the homogeneity, freedom from cracks, and purity of the specimen; and Crystolon (silicon carbide crystals) gave 400. Such a large difference between Alundum and Crystolon was hardly looked for, but is a real difference under these conditions of test. When a harder abrading grain is used, the difference becomes somewhat less but is still large.

Silicon is an element of relatively low specific gravity (2.5) and its general appearance does not suggest a hardness as great as that of glass. Actually, 2.7 was obtained for its abrasion hardness.

Three samples of Norton electrically fused mullite containing parallel elongated prism crystal growth were tested. Glass phase was present in all of them in amounts of 10, 15, and 50%, and therefore all results are thought to be lower than the actual abrasion-hardness of mullite because the glass phase is undoubtedly softer. The highest value found was 7.1 for the sides of the prisms in the coarsely crystalline sample No. 3 that was estimated microscopically to contain 85% mullite.

A sample of Norton electrically fused magnesia was colorless and transparent; its abrasion-hardness was 1.5.

IV. Experiments with Abrading Grains Other Than Quartz Sand

The use of different kinds of abrasive grains as abrading agents in the Zeiss machine has led to some interesting conclusions. Thus, in Table II it is shown that the artificial abrasives tested cut only twice as fast as the round-grain sand when used on the softest material investigated (plate glass), but the advantage of the artificial abrasives increased on harder materials until on Crystolon itself Alundum grain was nine times as good as standard sand and Crystolon grain was seventy-two times as good as standard sand.

TABLE II

RATIOS BETWEEN RELATIVE RATES OF CUTTING OF DIFFERENT MATERIALS BY DIFFERENT ABRASIVES OF ABOUT NO. 30 GRIT SIZE

Materials abraded		Multiplier showing superiority in rate of cutting for	
Kind	"Abrasion hardness" (standard sand)	Alundum over standard sand	Crystolon over standard sand
Plate glass	1	2.0	1.8*
Mineral quartz	5	3	3.3
Regular Alundum	38	4	12
Dense Crystolon	400	9	72

* This figure is probably in slight error on the low side

[4] Onondaga Pottery, Syracuse, N. Y.
[5] Jeffery-Dewitt Insulator Co., Kenova, W. Va.
[6] Champion Spark Plug Company, Ceramic Division, Detroit, Mich.

These results show that when the impact abrasion-hardness of a material compared to plate glass is determined with different kinds of abrasive grain, the relative numerical results are quite different depending on the hardness of the abrasive grain used for blasting, although in the present work the order of hardness was found to be the same in the cases studied. In the present paper, the term impact abrasion-hardness has been used only for results obtained with standard silica sand as the abrading agent, but if impact abrasion-hardness values were calculated using the harder Alundum or Crystolon abrasives, approximately the following values would be obtained.

TABLE III

IMPACT ABRASION-HARDNESS VALUES OF SEVERAL MATERIALS IF CALCULATED WHEN DIFFERENT KINDS OF ABRASIVES ARE USED

Material tested	Calculated impact-abrasion hardness using: Standard silica sand	Alundum grain (Al_2O_3)	Crystolon grain (SiC)
Plate glass	1.0*	1.0*	1.0*
Mineral quartz	5	3	2
Regular Alundum (Al_2O_3)	38	20	6
Dense Crystolon (SiC)	400	100	10
Molded boron carbide (B_4C)		2500	

* Taken as the basis for reference in each case.

This shows how the use of harder abrasive grains reduces the apparent impact-hardness differential between hard and soft materials. The value for molded boron carbide using Alundum abrasive grain for blasting has been included in order to show the extreme wear resistance of this material (Norbide) under these abrasion conditions.

The effect of grain size is an important factor in the Zeiss machine results. For instance, the relative rates of cutting for Alundum grain of three different grit sizes were found to be as follows on plate glass:

No. 24	No. 30	No. 36
1.16	1.00	0.74

No other results were obtained for No. 36 grain, but Nos. 24 and 30 Alundum grain also gave about these same relative rates when cutting mineral quartz and when cutting Alundum.

Acknowledgment

Acknowledgment is made of the services of David Armitage, who carried out most of the actual abrasion-hardness determinations. The samples of sillimanite-type spark-plug, chemical, and refractory porcelains were supplied through the kindness of F. H. Riddle, Champion Spark Plug Company, Ceramic Division; the hotel chinaware through the kindness of Edward Schramm, Onondaga Pottery Company; and the fused quartz and the Brazilian quartz crystal through the kindness of the Thomson Research Laboratory, General Electric Company. Thanks are extended to the directors of Norton Company for permission to publish this paper.

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WORCESTER, MASSACHUSETTS

THE FREEZING OF PYROMETRIC CONES*

By R. F. Rea† and M. C. Shaw‡

Abstract

Pyrometric cones are sometimes subjected to atmospheric or firing conditions which cause a misbehavior known as "freezing." Under such conditions, the cone may not come down until a higher temperature, sometimes two or three cones higher, is reached. Definite conclusions have not yet been reached as to the cause of this action. Through petrographic and X-ray analysis, however, certain definite ideas have been formulated which have served as a basis for the development of a series of nonfreezing cones. These cones have been used under conditions where freezing is ordinarily produced and were found to act normally, recording the true heat work.

I. Introduction

The increase in refractoriness of pyrometric cones under certain conditions of firing is known as freezing. Complaints have been made periodically that certain cones freeze, and there is evidence that cones 6 to 11 do freeze under certain conditions. There have been cases where cone 8 has been rendered so refractory as to remain standing after cone 10 has gone down (Fig. 1). In appearance a frozen cone is rough and its edges are sharp; a normal cone is smooth and glassy and its edges are well rounded.

Orton and Krehbiel[1] based their studies of this problem on the action of the feldspar, which is unquestionably the proper starting point. They assumed that freezing was due to interruptions in the progress of heat attainment which caused the crystallization of a refractory material. They attempted to reduce this tendency by using a relatively pure potash feldspar. This method apparently was not the solution because no improvement was noted.

Henderson and Caldwell[2] stated that by adding talc to the body, they produced a cone which has less tendency to freeze.

II. A Case of Cone Freezing

Freezing has been found most frequently in the coal-fired periodic kilns of the refractories, abrasive, and porcelain industries. One plant making high-grade fireclay refractories had cone 8 freezing in nearly every kiln. Pats of cones from this plant often showed cone 8 standing with cone 11, while cones 9 and 10 were down. The kilns at this plant were of the coal-fired, periodic, downdraft type, firing to cones 9 to 10 in about seven days. All of the fireboxes were fired at one time, and the time between firings varied from 45 minutes to occasionally two hours. The pyrometer in the crown of the kiln often showed as much as 250°F fluctuation in temperature between firings. The fuel used was a fairly high sulfur coal. The cones, on removal from the kiln, were usually covered with a heavy coat of fly-ash on one or two sides. Furthermore, the cones were so placed that they could easily have been chilled by a cold draft when the peepholes were opened. The peepholes were about 3 by 4 inches, and the kilns were usually under a negative pressure at this point.

From these observations, three possible causes of freezing were studied, namely, (1) the type of coal with its resulting kiln atmosphere, (2) fly-ash from the coal, and (3) fluctuating or irregular temperature gradient.

A study was made first of the temperature gradient at the point where the cones were set. A Champion sillimanite protection tube, 8 feet 7 inches, with a platinum-platinum rhodium thermocouple, 8 feet 8 inches, was placed in a kiln at the point where the cone pat was set. Temperatures were recorded for the last two days of the firing period.

At the beginning of the observation, the temperature at the point where the cones were set was 1245°F. At the end of the firing, 45 hours later, the temperature had risen to 2140°F, cone 9 was started, and cone 8 definitely frozen. During the last 12 hours of the firing, the average rate of

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (Refractories Division). Received April 17, 1936.

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[1] Edward Orton, Jr., and J. F. Krehbiel, "Influence of Different Feldspars on Freezing Behavior of Cones," *Jour. Amer. Ceram. Soc.*, **11** [4] 215–23 (1928).

[2] H. B. Henderson and J. H. Caldwell, "Increase in Refractoriness in Ceramic Bodies in Interrupted Heat Treatment," *ibid.*, **11** [11] 795–802 (1928).

FIG. 1.—Previously frozen cone 8, fired in a gas-fired laboratory kiln to cone 11[1] without deformation.

temperature increase was about 5° an hour. Although at no time did the temperature fall off more than 5°, there were periods when the temperature did not advance.

Cones set in the center of the kiln were found to freeze as readily as those set near the peepholes. Small peepholes of one inch were substituted for the larger ones but this change did not prevent the cones from freezing.

It was suggested that the deposit of fly-ash on the cones might be causing the cones to freeze. Instances were found, however, of cones that were frozen having no deposit of fly-ash.

Sulfur gases in a kiln atmosphere might act as a mineralizer, increasing the tendency toward crystallization, or to form $CaSO_4$ by reaction with the calcium oxide in the cones. Any $CaSO_4$ formed at a lower temperature, however, would dissociate at the temperature of cone 8 in an atmosphere of low-sulfur content. By using a high-sulfur coal, there would not be more than 1 or 2 millimeters vapor pressure of sulfur oxides in the kiln atmosphere. A cone 8 composition made up, using $CaSO_4$ as a partial replacement for $CaCO_3$, did not freeze when fired in the laboratory but rather came down ahead of cone 8. A frozen cone 8 analyzed 0.01% sulfur. From these observations it seems that the formation of calcium sulfate is in no way related to freezing.

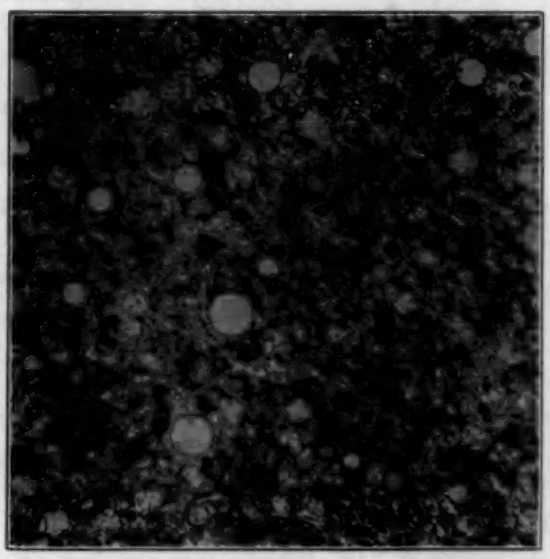

FIG. 2.

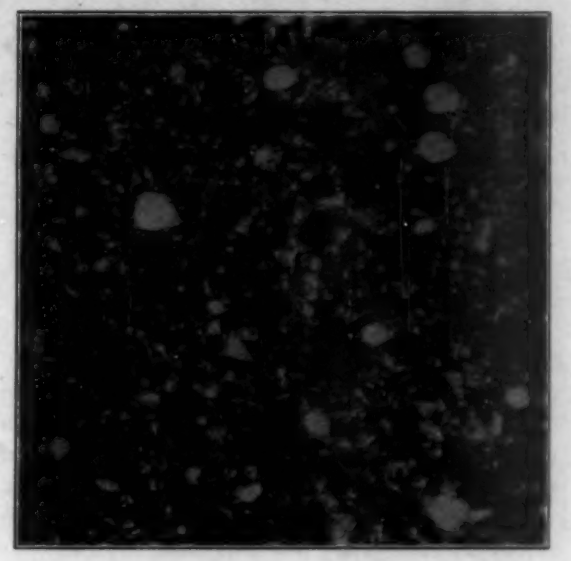

FIG. 3.

III. Microscopic Examination

A number of cones, frozen and normally fired, were examined with the petrographic microscope. The quartz grains showed practically no solution. The feldspar was isotropic or slightly anisotropic, the latter indicating incomplete melting. The feldspar grains in the frozen cones and those not frozen were very turbid, probably owing to the formation of mullite. The glass phase surrounding the quartz and fused feldspar grains was transparent in the case of cones which were not frozen but was cloudy or turbid in the frozen cones (Figs. 2 and 3).

Cones fired four times under freezing conditions showed an increased turbidity in the glass phase.

One X-ray powder photograph was made comparing a frozen cone with one that had not frozen.

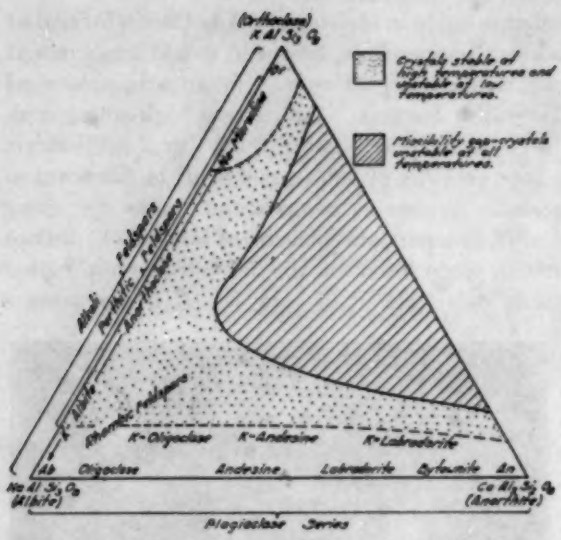

FIG. 4.—Chemical composition of the feldspars; triangular diagram of the system orthoclase–albite–anorthite. (From Karl Chudoba, The Determination of the Feldspars in Thin Section, p. 3. Tr. by W. Q. Kennedy, D. Van Nostrand & Co., 1933.)

The quartz lines were prominent in both cases; perhaps a little stronger in the case of the frozen cone. There was one strong line in the diffraction pattern of the frozen cone that was not present in the pattern of the cone which had not been frozen.

The development of a cryptocrystalline material in the glass phase was thus made evident.[3]

IV. Miscibility of Glasses Formed in Fired Cones

In the cone series from 4 to 27, two melts are formed when the cone is heated. One is the lime-alumina-silica melt which forms when the calcium oxide reacts with the kaolinite in the cones. The source of the other is the potash feldspar which melts at about cones 7 to 9. These liquids are miscible only to a limited extent during the progress of kiln firing.

It is known that in nature potash and lime feldspars do not form a continuous, isomorphous series. Soda feldspar, however, does form a continuous series with anorthite (Fig. 4). This would give the more complex liquid, with less tendency to devitrify, which the writers believe is needed.

McDowell[4] gave the deformation eutectic as follows.

$$\left.\begin{matrix}0.05\ MgO\\0.35\ CaO\\0.60\ KNaO\end{matrix}\right\} 0.7415\ Al_2O_3 \quad \{4.81\ SiO_2$$

[3] This phase of the work is now being studied at Pennsylvania State College under N. W. Taylor on a grant from the Edward Orton, Jr., Ceramic Research Foundation.

[4] S. J. McDowell, Thesis, Ohio State University, 1917.

Since the potash feldspar-soda feldspar eutectic is in the ratio of about 3 to 7, the six-component deformation eutectic was assumed to be approximately

$$\left.\begin{matrix}0.05\ MgO\\0.35\ CaO\\0.18\ K_2O\\0.42\ Na_2O\end{matrix}\right\} 0.74\ Al_2O_3 \quad \{4.8\ SiO_2$$

Cones made up according to this formula had a pyrometric cone equivalent of 2 to 3. Using this composition as a basis for development, a cone deforming with the regular cone 8 was produced by adding clay and silica; the alumina-silica ratio was maintained at 1:10 as is done in the regular cone series. Preliminary tests indicated that these new cones had no tendency to freeze.

In finally compounding the cone batches, it was found that through the elimination of the MgO a cone could be developed which had no more tendency to freeze and was better suited to the time and temperature interval of bending that is necessary in cone deformation. The MgO was therefore eliminated from further consideration as a cone batch constituent.

Cones 4, 5, and 7 were made up and tested with apparently the same results.

After the nonfreezing cone 8 was so adjusted in composition that it checked exactly the standard cone 8, the cones were sent to various ceramic plants where conditions conducive to freezing were known to prevail.

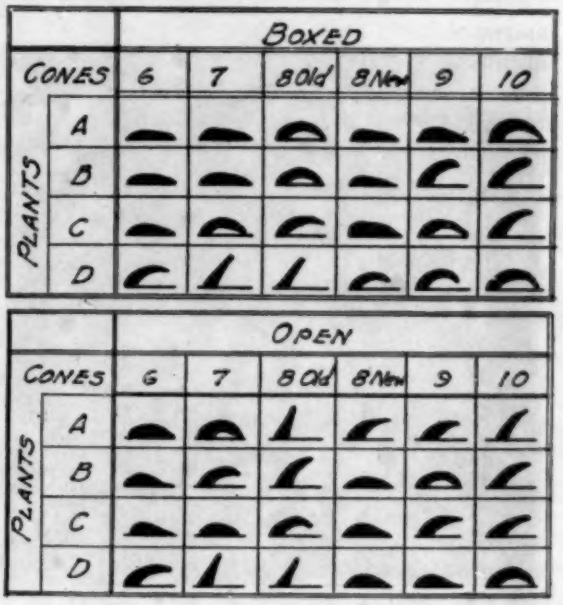

FIG. 5.

One company tested the cones in four different plants. At each plant, a new nonfreezing cone 8 was set in a pat containing cones 6, 7, 8, 9, and 10 of the regular stock. Two pats of each set of cones were placed in each kiln; one pat was set in the open where it would be exposed to the kiln atmosphere and the other pat was protected from flame contact and much of the kiln gases. The results are given diagrammatically in Fig. 5.

FIG. 6.—Nonfreezing cone 8 (4D), fired under freezing conditions with standard cones.

Freezing of the old cones both in the boxed and open settings was found, but the nonfreezing cones were not affected by the freezing conditions.

V. Summary

(1) Freezing is usually brought about in hand-fired periodic kilns using coal as fuel.

(2) The position in the kiln where the cones are set has little relationship to the freezing.

(3) Fly-ash, in itself, bears no relationship to freezing.

(4) The effect of kiln atmosphere upon freezing is not definitely known, but the writers are inclined to believe there is some relationship.

(5) An irregular temperature gradient bears some relationship to freezing as is evidenced through firing tests.

(6) The soda-feldspar cones show a greatly reduced tendency to freezing.

(7) The cause of the freezing of cones has not yet been definitely determined.

Acknowledgments

The authors wish to acknowledge the assistance given by William J. McCaughey for his aid in the interpretation of the petrographic studies, Frank H. Riddle for the use of the 106-inch Champion sillimanite protection tube, and the Charles Taylor and Sons Company and General Refractories Company for their aid in making various tests in connection with this investigation.

PHYSICAL-CHEMICAL REACTIONS IN FIRING WHITEWARE*

BY T. N. MCVAY

ABSTRACT

The present knowledge concerning reactions which take place during the heat treatment of clay, feldspar, and silica is discussed as well as the relations of these three to the ternary system K_2O–Al_2O_3–SiO_2. The manner of growth of mullite crystals in feldspar has been studied. Additional experimental data as evidenced by the thermal-expansion curves of clay-feldspar and clay-silica mixtures previously fired at high temperatures are presented.

I. Introduction

In whiteware products the system K_2O–Al_2O_3–SiO_2 is primarily used, although such ceramic products are not fired for a long enough time to attain equilibrium conditions. Inasmuch as the major raw materials used in whiteware bodies are potash feldspar or microcline, clay, and silica and these are found in nature, they contain accessory minerals which introduce oxides such as Na_2O, CaO, MgO, TiO_2, and Fe_2O_3. These oxides influence the temperature of glass formation as well as the viscosity of the glass phase and act as mineralizers for the promotion of the crystallization of mullite. They also aid in the solution of the quartz and are important. These impurities, however, usually exist in comparatively small amounts, and the effects of their presence are little known. This paper, therefore, will deal only with the three major constituents, namely, feldspar, clay, and silica.

Figure 1, the ternary diagram for the system K_2O–Al_2O_3–SiO_2, shows the location of typical

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (White Wares Division). Received April 23, 1936.

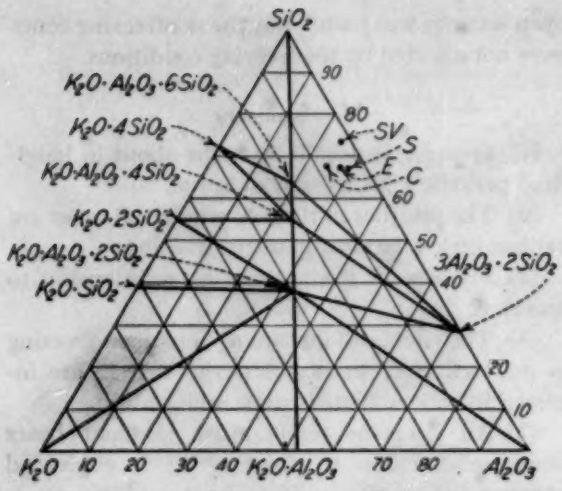

FIG. 1.—*E* = electrical porcelain; *C* = ceramic body; *SV* = semivitreous; *S* = sanitary ware.

semivitreous, electrical porcelain, sanitary ware, and high feldspar floor-tile bodies. The field in which these bodies is located is a triangle, the apices of which are SiO_2–$3Al_2O_3 \cdot 2SiO_2$–$K_2O \cdot Al_2O_3 \cdot 6SiO_2$. For plotting such compositions it is assumed that the raw materials have ideal compositions, but deviations from these ideal compositions would influence only slightly the locations of the bodies. The actual shift would be toward silica because feldspar and ball clay contain free quartz. The trends of the boundary curves in the system are not known, but it is believed that the final products of crystallization of whiteware bodies, heated to a glass and then cooled under equilibrium conditions, would be feldspar, mullite, and tridymite. The amount of each compound present could be determined by the location of the whiteware body in the triangle.

To establish this equilibrium would be difficult, inasmuch as the viscosity relations in melts with high silica contents are such that it would require a long period of time with very slow cooling to obtain the compounds named.

The known facts concerning the pyrochemical behavior of feldspar, clay, and silica are briefly reviewed.

(1) Feldspar

Morey and Bowen[1] prepared pure potash feldspar by crystallization in a steel bomb with water as the mineralizer. They located its incongruent melting point temperature (Fig. 2) by increasing the temperature rather than lowering it, because potash feldspar has never been crystallized from its own melt. The temperature of its incongruent melting point is about 1170° and at this point potash feldspar dissociates into leucite and glass. With an increase in temperature, the leucite crystals become larger but they disappear at a temperature of 1530°. North Carolina microcline has a final melting temperature of 1440°, while that of comparatively pure sanidine feldspar is 1460°. Like all natural potash feldspars, these minerals contain some albite, but there is no noticeable change in the incongruent melting point compared with that of the synthetic mineral. The approximate melting point of leucite has been placed at 1800°, and the melting point of silica is located at 1713°. The general trend of the liquidus line has been given, but the composition and temperature of the silica-feldspar eutectic has not been located.

(2) Clay

It is agreed that clay decomposes at a temperature of about 700° with the loss of chemically combined water and the destruction of its crystal lattice structure. The material at this temperature is probably amorphous, inasmuch as the X-ray

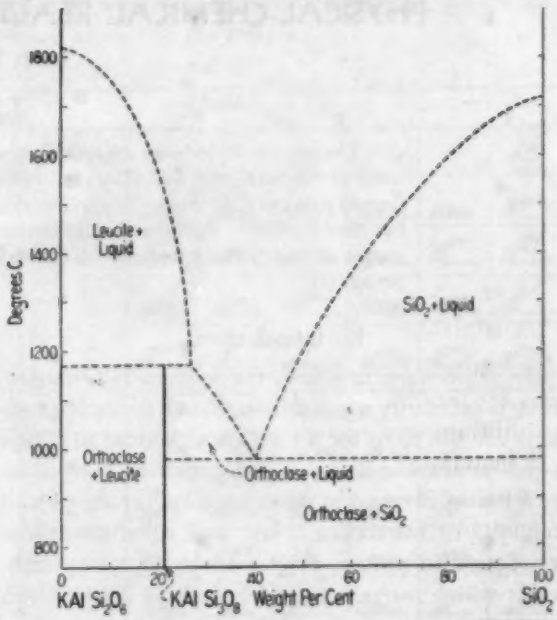

FIG. 2.—System $KAlSi_3O_8$–SiO_2 (G. W. Morey and N. L. Bowen, *Amer. Jour. Sci.*, 5th Ser., **4**, 1–21 (1922), p. 10; *Jour. Amer. Ceram. Soc.*, **16** [10] 501(1933), Fig. 54.

[1] G. W. Morey and N. L. Bowen, "The Melting of Potash Feldspar," *Amer. Jour. Sci.*, 5th Ser., **4**, 1–21 (1922).

shows no diffraction pattern. At a temperature of about 925° an exothermic reaction takes place which, according to Insley and Ewell,[2] is due to the crystallization of γ-alumina. With samples quenched from a temperature of 1000°, an X-ray examination showed the presence of mullite. McVay and Thompson[3] obtained definite X-ray patterns of mullite from samples of clay heated slowly to 950°. The amount of mullite increased gradually with an increase in temperature or the mullite became better crystallized. With some clays, cristobalite also crystallized at temperatures of about 1225°. This was verified by means of X-ray diffraction patterns and also by thermal-expansion curves, but every clay does not show the latter phenomenon.

(3) Silica

The changes taking place in heating silica have been investigated by Fenner.[4] In American practice, quartz is the usual source of silica used in whiteware bodies and therefore will be the only source of silica discussed in this paper. Quartz

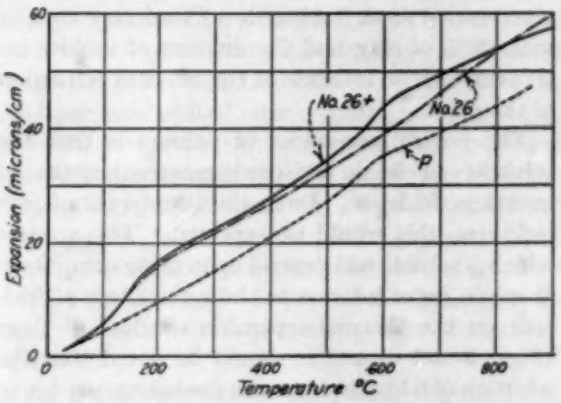

FIG. 3.—Expansion curves: No. 26 = S G P ball clay, cone 11; No. 26+ = S G P ball clay 80%, flint 20%, cone 11; *P* = porcelain body containing S G P ball clay, cone 11½.

changes from the α- to β-form at 573.3°. This change is rapid, reversible, and complete. In the presence of a flux, quartz inverts sluggishly to tridymite at 870° and, in the absence of a flux, it sluggishly inverts to cristobalite at 1250°. Both of these inversions are below the firing temperatures of most whiteware bodies.

II. Inter-Relations of These Materials

(1) Silica and Clay

No reactions are ordinarily involved in the addition of silica to comparatively pure clays used in the manufacture of whiteware. The silica-alumina eutectic found by Bowen and Greig[5] is at 1545°, which is above the firing temperature of ordinary whiteware bodies. An addition of silica increases the coefficient of expansion of clay-silica mixtures as shown in Fig. 3. This, however, is due to a mixture rather than to any reactions. Therefore within the limits of the firing range of such bodies, in so far as the silica–alumina system is concerned, we are dealing with mixtures.

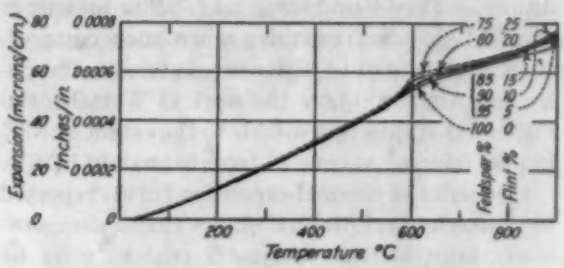

FIG. 4.—Thermal-expansion curves of feldspar-flint mixtures.

(2) Silica-Feldspar

As has been previously pointed out, the silica–leucite system has not been thoroughly investigated and has not been extended to include kaliophilite ($K_2O \cdot Al_2O_3 \cdot 2SiO_2$). Feldspar will take silica into solution, the amount going into solution being dependent upon temperature if equilibrium conditions are maintained. The solubility of quartz in feldspar has been investigated by Klein,[6] Parmelee and Amberg,[7] and others. It is generally believed that quartz is difficultly soluble in feldspar. Klein[6] says that quartz starts to dissolve slightly in feldspar at 1340°. Parmelee and

[2] H. Insley and R. H. Ewell, "Thermal Behavior of Kaolin Minerals," *Jour. Research Nat. Bur. Stand.*, **14**, 615–27 (1935); R.P. 792.

[3] T. N. McVay and C. L. Thompson, "X-Ray Investigation of the Effect of Heat on China Clays," *Jour. Amer. Ceram. Soc.*, **11** [11] 829–41 (1928).

[4] C. N. Fenner, "The Stability Relations of the Silica Minerals," *Amer. Jour. Sci.*, 4th Ser., **36**, 331–84 (1913).

[5] N. L. Bowen and J. W. Greig, "The System Al_2O_3–SiO_2," *Jour. Amer. Ceram. Soc.*, **7** [4] 238–54 (1924); correction, *ibid.*, [5] 410.

[6] A. A. Klein, "Constitution and Microstructure of Porcelain," *Trans. Amer. Ceram. Soc.*, **18**, 377–423 (1916).

[7] C. W. Parmelee and C. R. Amberg, "Solubility of Quartz and Clay in Feldspar," *Jour. Amer. Ceram. Soc.*, **12** [11] 699–710 (1929).

Amberg[7] report that 10% of quartz is soluble in high soda feldspar at 1375° and 28% is soluble at 1425°. With a high potash feldspar, quartz is insoluble at 1400° and 4% is soluble at 1425°. The furnace in each case was held at the desired temperature for 6 hours. Because 1375° is above the inversion point of quartz to tridymite and cristobalite and because quartz was found in melted feldspar at this temperature, it must be concluded that the quartz had not reached equilibrium conditions. They found some cristobalite present in the feldspar-silica mixtures when such compositions were heated to high temperatures. Parmelee and Amberg[7] quote the work of Wetzel,[8] who claimed that quartz is soluble to the extent of 50% in pure feldspar at cone 15 (approximately 1410°).

One series of thermal-expansion curves reported by Parmelee and McVay[9] shows that a comparatively large increase in quartz content gives no great change in the inflection of the thermal-expansion curve at the α- to β-quartz inversion point (Fig. 4). The original feldspar contained about 13% of quartz. If 25% of quartz were added, there would be 44 parts of quartz to 100 parts of feldspar. It should also be noted that there are no signs of any inflections at the α- to β-cristobalite or the α- to β-tridymite inversion temperatures.

(3) Clay and Feldspar

Parmelee and Amberg[7] report that the solution of clay in potash feldspar starts at 1250°, and at 1425° the solubility is 20.5 parts of clay for 100 parts of feldspar.

Peck[10] studied the solubility of clay in feldspar by making mixtures of Maine feldspar with different proportions of equal parts of Kentucky ball clay and North Carolina kaolin. He heated these to 1400° and held them at this temperature for three hours. His results show that the refractive index of the glass increased until 20% of clay was added. Further additions of clay had no effect on the refractive index of the glass, but there was an increase in the amount of "sillimanite" with an increase in clay content. He found that "sillimanite" was developed at the temperature of heating and that slow cooling did not increase the amount present. The Bureau of Standards[11] reported that mullite crystals were

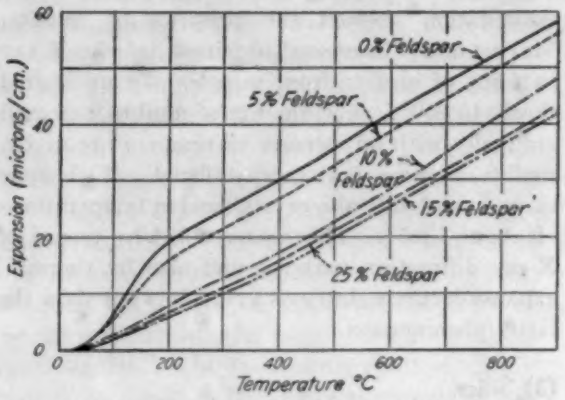

FIG. 5.—Expansion curves for Georgia kaolin with feldspar additions, cone 11.

present in melts of orthoclase, kaolin, and potters' flint, which contained at least 30% of clay, and that those with less than this amount consisted mainly of glass. The indices of refraction of the glass varied from 1.48 with 10% of clay to 1.54 with 90% of clay and the amount of mullite increased with an increase of the index of refraction of the glass.

The general consensus of opinion is that the solubility of clay in feldspar is greater than that of quartz in feldspar. From the standpoint of particle size, this would be expected. The amount which is soluble will depend upon firing conditions. It might be of interest to show the effect of feldspar on the thermal-expansion conduct of clays (Figs. 5 and 6) and it should be noted that the addition of feldspar decreases the inflections due to inversions of the silica minerals. It is believed that the feldspar dissolves the cristobalite or the amorphous silica set free during the decomposition of the clay molecule and thus the usual expansion is not present.

The other possible explanation is that the body becomes vitreous and prevents the expansion of the silica.

III. The System Clay–Feldspar–Silica

It is difficult to trace and account for all the changes taking place when mixtures of clay, feld-

[8] K. Wetzel, "Influence of Grain Size on the Solubility of Quartz in Feldspar in Porcelain Fire," *Ber. deut. keram. Ges.*, **5**, 2 (1924); *Ceram. Abs.*, **4** [5] 137 (1925).

[9] C. W. Parmelee and T. N. McVay, "An Investigation of the Properties of Some Feldspars," *Univ. Ill. Eng. Expt. Sta. Bull.*, No. 233 (1931).

[10] A. B. Peck, "The Effect of Time and Temperature on the Microstructure of Porcelain," *Jour. Amer. Ceram. Soc.*, **2** [3] 175–94 (1919).

[11] Anon., "Vitrification of Ceramic Bodies," *Bur. Stand. Tech. News Bull.*, No. 133, pp. 70–71 (1928).

spar, and quartz are heated. If the composition and temperature of the possible eutectic between these three materials were known, it would be easier to predict the changes taking place. According to our present knowledge, clay first dissociates at about 700°, mullite begins to form at about 1000°, and in some cases γ-alumina is present. At 1170° feldspar melts incongruently and starts to take both alumina and silica into solution.

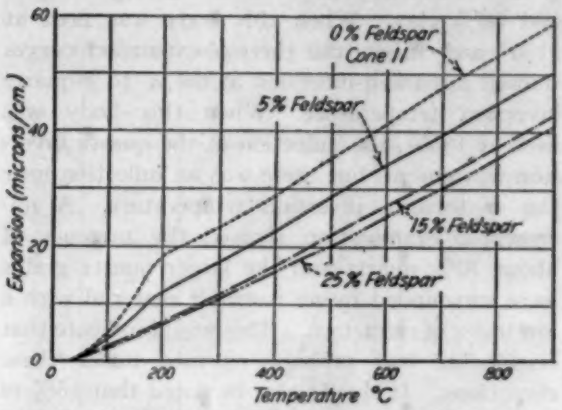

FIG. 6.—Expansion curves for Kentucky ball clay No. 8 with feldspar additions, cone 10.

Norton[12] found that with whiteware bodies held at a temperature of 1120° for 10,000 minutes the feldspar was melted, that mullite had started to crystallize, and that quartz was slightly corroded under these conditions. He does not give the type of feldspar used and this may account for the discrepancy in the melting temperature of the feldspar as compared with the results obtained by Morey and Bowen.[1] It is possible that the presence of clay lowered the melting point of the feldspar.

As the temperature is further increased, pores are filled with the liquid glass and surface tension effects tend to draw the materials into closer union. The clay and quartz go into solution progressively, and mullite crystallizes in the melted feldspar. These crystals become larger with increasing time of heat treatment and with increase of temperature. The start of crystallization may be due to saturation with a slight drop in temperature, as pointed out by Peck,[10] or the labile state of saturation may be reached by continuous solution of the clay. Mullite is produced in whiteware in two ways, (1) directly from the dissociation of clay and then by crystal growth and (2) by solution of clay in the feldspar with subsequent crystallization. Norton[12] has noted that mullite crystals present in melted feldspar were not continuous with the clay grains. Kraner[13] reported that mullite was not present in the interior of large melted feldspar grains.

To study this problem, the writer prepared an electrical porcelain body which contained 30% A No. 1 English china clay, 20% Kentucky Old Mine No. 4 ball clay, 30% high-grade North Carolina microcline, and 20% potters' flint. Several batches were made with the following sizes of feldspar:

No.	Mesh feldspars
1	20– 35
2	35– 48
3	48– 60
4	60– 80
5	80–100
6	100–150
7	150–200

These batches were blunged with the proper amount of water, allowed to dry to the proper working consistency, and test bars, formed in iron molds, were fired to cone 12 down in 16 hours. Thin sections, prepared from mixtures 1, 3, 5, and 7, were examined with a petrographic microscope. The examination showed that crystallization starts at the clay boundaries of the feldspar grains and that the first mullite crystals are oriented nearly normal to the clay interface. No mullite crystals are noticeable in the interior of large feldspar grains. Crystals form in the interior of smaller feldspar grains. These crystals are not normal to the clay interface but appear to radiate from common centers.

Klein,[6] Peck,[10] Insley,[14] Watts,[15] Parmelee and McVay,[9] Norton,[12] and others have studied the effect of firing on the development of mullite in whiteware bodies. Klein[6] came to the conclusion that temperature had the greatest effect on mullite development. Peck[10] and Norton[12] have shown that long periods of firing increase the development of mullite as well as the solution of the quartz. This further indicates that the components of whiteware have not reached a state of equilibrium.

[12] C. L. Norton, Jr., "The Influence of Time on the Maturing Temperature of Whiteware Bodies: II," *Jour. Amer. Ceram. Soc.*, **14** [3] 192–206 (1931).

[13] H. M. Kraner, "Glass Phase in Porcelain," *ibid.*, **12** [6] 383–99 (1929).

[14] H. Insley, "The Microstructure of Earthenware," *ibid.*, **10** [5] 317–26 (1927).

[15] A. S. Watts, "The Progress of Vitrification and Solution in Some Porcelain Mixtures," *ibid.*, **2** [5] 400–409 (1919).

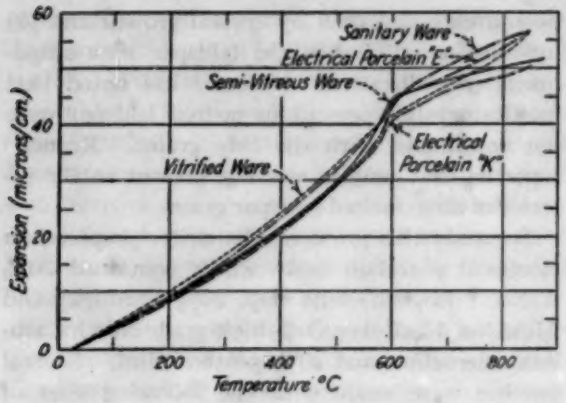

FIG. 7.—Thermal-expansion curves for several body compositions fired at cone 9.

One of the problems is to account for the leucite which is formed when feldspar melts incongruently. Shigemune[16] says that the fibers developed in the feldspar present in porcelain bodies are leucite. His position is untenable because the optical properties of leucite and mullite are so widely different and fewer fibers develop in the melted feldspar of a whiteware body when the clay content is small. In so far as the writer is aware no other investigator has reported the presence of leucite in whiteware bodies.

With one exception, quartz is the only form of silica that has been reported as being identified in vitreous porcelain bodies. The writer, however, on one occasion found that a quartz grain had penetrated into a bleb in a porcelain body. The edge of this grain had inverted into a lower form of silica while the remainder of the grain showed no trace of cristobalite or tridymite. Geller, Evans, and Creamer[17] obtained interesting data by preparing whiteware bodies with carefully sized materials and firing them at several temperatures. One of these contained 35% potters' flint with a grain size of less than 10 microns, 15% feldspar, and 50% clay. When this body was fired at 1150° and 1250°, the thermal-expansion curves showed a marked inflection at the α- to β-quartz inversion temperature. When this body was fired at 1350°, the inflection at the quartz inversion was absent, but there was an inflection near the cristobalite inversion temperature. A microscopic examination showed the presence of about 10% quartz and the larger quartz grains were surrounded by an isotropic material with a low index of refraction. This would indicate that cristobalite had probably formed under these conditions. It should also be noted that 15% of feldspar might not be sufficient to dissolve all of the lower forms of silica present at this temperature. The thermal-expansion curves of most whiteware bodies do not show traces of cristobalite (Fig. 7). Peck[19] found that quartz was noticeably dissolved in porcelain bodies at 1290° with ten hours of heating and Norton[12] found that a slight amount of solution had started at 1120° when a whiteware body was fired for 10,000 minutes.

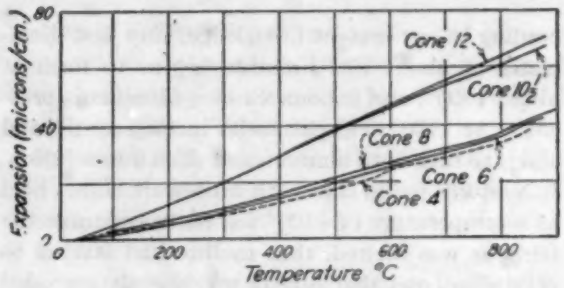

FIG. 9.—Expansion curves for feldspar No. 5, English knob pink feldspar.

Studies on the reaction of silica in whiteware bodies were made by Westman,[18] who substituted silica glass for potters' flint (ground quartz) in a porcelain body. He showed that silica glass lowered the thermal expansion and reduced the

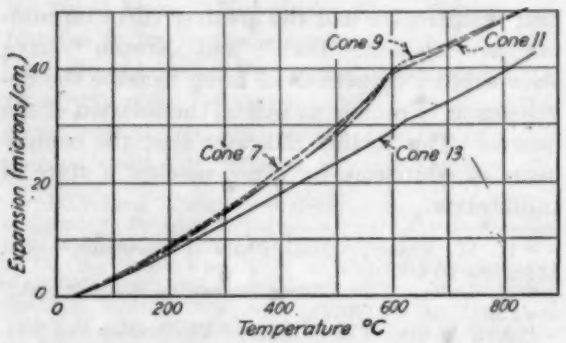

FIG. 8.—Expansion curves for electrical porcelain body.

[16] Ryoichi Shigemune, "Microstructure of Porcelain Insulator," *Jour. Jap. Ceram. Assn.*, **35** [420] 615–21 (1927); *Ceram. Abs.*, **7** [3] 178 (1928).

[17] R. F. Geller, D. N. Evans, and A. S. Creamer, "Effects of Particle Size of a Potters' Flint and Feldspar in Whiteware," *Bur. Stand. Jour. Research*, **11** [5] 327–40 (1933); R.P. 594.

[18] A. E. R. Westman, "Use of Fused Silica as a Raw Material in the Manufacture of Porcelain," *Jour. Amer. Ceram. Soc.*, **11** [2] 82–89 (1928).

maturing temperature of porcelain. He also found that there was a slight development of mullite around some of the grains of silica glass and that these grains were strained.

An increase in firing temperature of some bodies, particularly those which contain a moderate amount of feldspar, shows a decrease in the thermal expansion (Fig. 8). An increase in firing temperature of feldspar causes an increase in the thermal expansion of the substance (Fig. 9), while with whiteware bodies an increase in temperature causes a decrease in the thermal expansion. It is rather difficult to explain this difference in the behavior of feldspar and whiteware bodies. Figure 10 is taken from the work of Shearer and Wyckoff[19] and shows the expansion characteristics of some materials entering into the compositions of whiteware bodies.

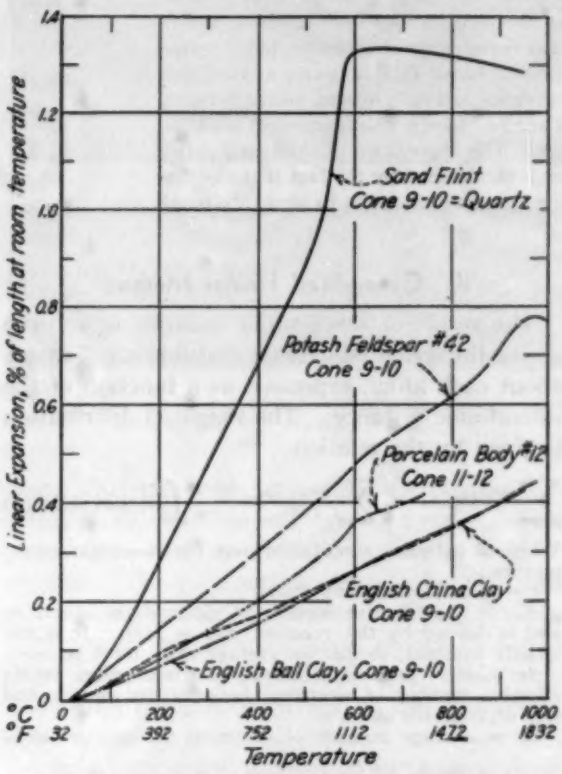

FIG. 10.—Comparison of the linear thermal expansions of the commonly used individual constituents of a whiteware body. (These results were obtained on the materials which had been separately fired to the same temperature at which the porcelain body is matured.)

Kraner[13] has devoted a considerable amount of time to the study of the glass phase in whiteware bodies, but this problem remains one of the most vexing in the study of these products. Morey and Bowen[1] have shown that glass in the melted feldspar is strained, owing to the contraction of leucite during cooling, because leucite has a contraction at its inversion point which is 700°. It has not been determined whether or not such strains are set up in glass which contains mullite crystals. The thermal expansion of mullite is considerably less than that of melted feldspar but there are no inversions. If the data of Mayer and Havas are used for the cubical expansion of the oxides present in melted feldspar, it can be shown by calculations that the solution of as much as 20% of clay in feldspar will cause but a slight lowering of the thermal expansion of the glass. Furthermore, if the commonly accepted figures for elasticity and tensile strength of oxides present in glasses are considered, it can be shown that the tensile strength and elasticity of the feldspar glass is only slightly affected by the solution of 20% of clay.

Inasmuch as the volume of melted feldspar is about 10.5% greater than an equivalent weight of the natural mineral, feldspar should aid in decreasing the shrinkage of the fired whiteware body. The volume of silica glass is approximately 19.5% greater than that of quartz and if quartz goes into solution the silica should exert a similar effect.

Acknowledgment

The writer wishes to thank C. W. Parmelee for the use of Figs. 3, 5, 6, 8, and 9, which were loaned from the files of the Department of Ceramic Engineering, University of Illinois, and which have not previously been published.

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[19] W. L. Shearer and W. R. Wyckoff, "Thermal Expansion of Whiteware Materials and Bodies over a Wide Range of Temperatures," *Ceramist*, 7 [6] 349–85 (1926); *Ceram. Abs.*, 5 [7] 223 (1926).

FOURIER ANALYSIS OF X-RAY PATTERNS OF VITREOUS SiO_2 AND B_2O_3*

By B. E. Warren, H. Krutter, and O. Morningstar

Abstract

The X-ray scattering curves for vitreous SiO_2 and B_2O_3 are obtained in a vacuum camera, using monochromatic Mo and Cu radiation. A Fourier analysis of the scattering curve gives directly a curve representing the distribution of neighboring atoms about any one atom. For SiO_2, the distribution curve establishes definitely the tetrahedral silicon-oxygen network. The distribution curve for B_2O_3 indicates a triangular coördination, each boron surrounded by three oxygens, and each oxygen shared between two borons. The interatomic distances which are found are in good agreement with the values found in crystalline silicates and borates. The importance of the new Fourier method of analysis of glass diffraction patterns is emphasized by the fact that the distribution curves which are obtained are unique, no assumptions as to structure being involved.

I. Introduction

There are two methods for interpreting the X-ray diffraction patterns of noncrystalline materials such as glasses. By the first method, one guesses the distribution of atoms surrounding each atom in the material, making full use of all the information which has been obtained from crystal-structure determinations, such as interatomic distances, bond angles, and coördination numbers. From the approximate model, obtained in this way, the expected X-ray intensity curve is calculated and compared with the experimental curve. Various changes are then made in the proposed structure until a satisfactory agreement is obtained between calculated and observed intensity curves. A number of examples of the use of this method have been reported.[1]

By the second method, a Fourier analysis is made of the experimental X-ray scattering curve, obtaining directly an average radial distribution of atoms surrounding each atom. Although the Fourier method requires a very accurate scattering curve out to large values of $\frac{\sin\theta}{\lambda}$, it is a straightforward unique method, and hence to be preferred. The generalized Fourier method will be outlined briefly, and the method then applied to the X-ray scattering curves of vitreous SiO_2 and B_2O_3.

II. Generalized Fourier Method[2]

The result of the Fourier analysis is a curve giving the weighted average distribution of atoms about each atom, expressed as a function of the interatomic distance. The weighted distribution is given by the relation

$$\sum K_m 4\pi r^2 \rho_m = \sum K_m 4\pi r^2 \rho_0 + \frac{2r}{\pi}\int_0^\infty si(s)\sin rs\, ds \quad (1)$$

Where Σ indicates summation over the molecular composition.

r = distance from any atom.

K_m = the effective number of electrons in atom, m, and is defined by the relation, $K_m = f_m/f_e$. It is not strictly constant, so that an average value must be used.

$4\pi r^2 \rho_m dr$ = number of atoms, each multiplied by its effective number of electrons, between distances r and $r + dr$, from the atom, m.

ρ_0 = average number of electrons per unit volume.

$$s = 4\pi\frac{\sin\theta}{\lambda}.$$

$$i(s) = \frac{I_{eum} - \Sigma f^2_m}{f_e^2}$$

I_{eum} = the experimental intensity of unmodified scattering in electron units per molecule.

f_m = atomic scattering factor for atom, m.

$f_e = \frac{\Sigma f_m}{\Sigma Z_m}$ = average f per electron.

Z_m = atomic number of atom, m.

The curve, $si(s)$, is obtained directly from the experimental X-ray scattering curve, and the integration involved in equation (1) carried out either graphically or with a harmonic analyzer. All the other constants in equation (1) being known, the quantity, $\sum K_m\ 4\pi r^2 \rho_m$, is obtained directly. The meaning of this quantity can be best explained in the application to SiO_2 and B_2O_3.

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* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (Glass Division). Received April 13, 1936.

[1] (*a*) B. E. Warren, "X-Ray Determination of Structure of Glass," *Jour. Amer. Ceram. Soc.*, **17** [8] 249–54 (1934).

(*b*) B. E. Warren and A. D. Loring, "X-Ray Diffraction Study of the Structure of Soda-Silica Glass," *ibid.*, **18** [9] 269–76 (1935).

[2] The complete theory of the generalized Fourier method will be published soon, probably in *Jour. Chem. Phys.*

III. Experimental

The X-ray diffraction patterns were made in a cylindrical camera of 4.40 centimeters radius, the camera being evacuated to eliminate air scatter-

FIG. 1.—X-Ray diffraction patterns of vitreous B_2O_3 taken with CuKα- and MoKα-radiation.

ing. Patterns were made with both CuKα- and MoKα- radiation; in both cases the radiation was monochromated by reflection from a rock-salt crystal. The glass samples were cylindrical rods about 1 millimeter in diameter. The diffraction patterns for vitreous B_2O_3 are shown in Fig. 1. Microphotometer records of the films were changed to intensity curves in the usual way. The intensity curves so obtained were corrected for polarization and absorption in the cylindrical sample, and the Cu and Mo curves then fitted together. The results obtained from the Cu patterns are best for small values of $\frac{\sin\theta}{\lambda}$, while the the Mo radiation gives the intensity curve out to large values of $\frac{\sin\theta}{\lambda}$. Combining the results obtained with the two kinds of radiation has been found to be a satisfactory method. The final experimental intensity curves for SiO_2 and B_2O_3 are shown in Figs. 2 and 3.

IV. Results for Vitreous B_2O_3

The intensity curve as obtained from the microphotometer record is in arbitrary units. It is put upon an absolute basis by making use of the fact that the scattering curve for any material approaches independent scattering at large values of $\frac{\sin\theta}{\lambda}$. Curve B (Fig. 3), the independent unmodified and modified scattering,[3] is accordingly drawn to such a scale that curves A and B approach one another at large values of $\frac{\sin\theta}{\lambda}$. Figure 4 gives the curve $si(s)$ for B_2O_3, obtained from the curves of Fig. 3. The scale of abscissae, $2.55S$, is chosen for convenience in using a Coradi harmonic analyzer to evaluate the integral in equation (1).

The other quantities in equation (1) are readily computed. ΣK_m is the number of electrons per B_2O_3 and is hence $2 \times 5 + 3 \times 8 = 34$. ρ_0 is the number of electrons per A^3 and is calculated from the density and molecular weight.

$$\rho_0 = \frac{\rho N \times 10^{-24}}{M} \Sigma K_m = \frac{1.84 \times 6.06 \times 10^{23} \times 10^{-24} \times 34}{69.8} = 0.544.$$

K_m is the effective number of electrons in atom, m. The best average values for boron and oxygen are calculated as $K_B = 4.5$, $K_0 = 8.33$. The final radial distribution curve for vitreous B_2O_3 is shown in Fig. 5.

In the interpretation of a distribution curve such as Fig. 5, there are two quantities which are of importance: the positions of the peaks give interatomic distances, and the areas under the

[3] From tables of f and Σf^2, A. H. Compton and S. K. Allison, X-Rays in Theory and Experiment, pp. 781–82. D. Van Nostrand Co., Inc., New York, 1935.

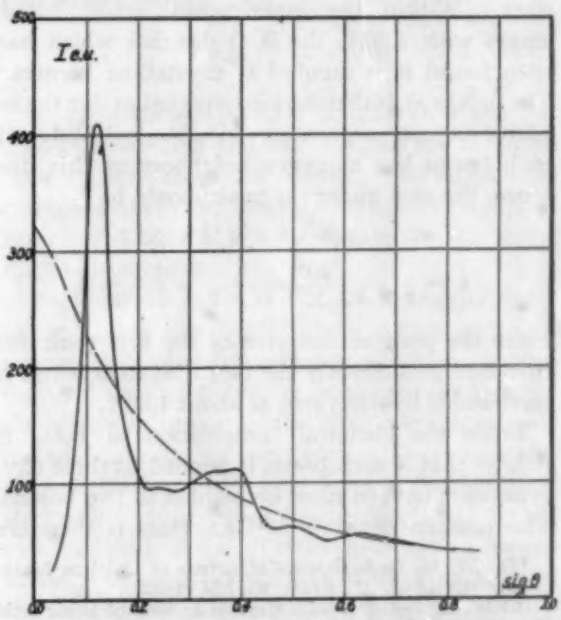

FIG. 2.—X-ray intensity curve for vitreous SiO_2 in e. u. per SiO_2; dashed line, independent scattering per SiO_2.

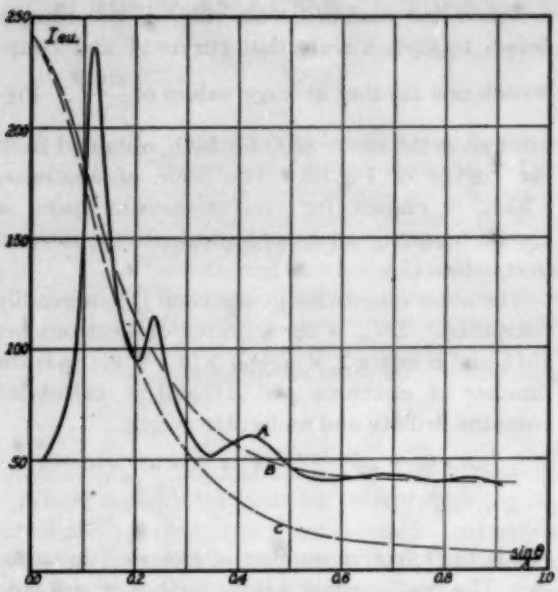

FIG. 3.—(*A*) X-ray intensity curve for vitreous B_2O_3 in e. u. per B_2O_3; (*B*) independent scattering per B_2O_3, modified plus unmodified; (*C*) unmodified independent scattering per B_2O_3.

peaks give the number of pairs of atoms at that distance of separation. The small peak at 0.8*A* is not real and is due to the fact that the intensity curve can not be obtained accurately out to sufficiently high values of $\frac{\sin\theta}{\lambda}$. The first real peak occurs at about $r = 1.39A$ and has an area 469 elect.[2] Within the experimental error, 1.39*A* agrees with 1.36*A*, the B–O distance which has been found in a number of crystalline borates.[4] The first peak is therefore interpreted as due to the boron–oxygen separation of about 1.39*A*. If each boron has *n*-oxygen neighbors at this distance, the area under the peak should be

$$A = (2 \times 4.5 \times n \times 8.33)\,2$$

$$n = \frac{469}{2 \times 4.5 \times 8.33 \times 2} = 3.1 \sim 3$$

From the position and area of the first peak one therefore gets directly the fact that each boron is surrounded by 3 oxygens at about 1.39*A*.

From the chemical composition of B_2O_3, it follows that if each boron is bonded to three oxygens, each oxygen must be bonded to two borons. The random network in B_2O_3 glass is therefore built up on triangular coördination, each boron at the center of a triangle of three oxygens, each oxygen bonded to two borons, with the two bonds presumably roughly diametrically opposite.

The second distance of separation will be that of oxygen–oxygen,

$$O\text{–}O = 1.39\sqrt{3} = 2.40A,$$

in good agreement with the observed peak at about 2.42*A*. The third distance of separation is that of boron–boron. Assuming that the two bonds to an oxygen are roughly diametrically opposite,

$$B\text{–}B = 1.39 \times 2 = 2.78A.$$

Since each boron will have three boron neighbors, the area of this peak would be

$$A = 2 \times 4.5 \times 3 \times 4.5 = 120 \text{ elect.}^2$$

Subtracting an area of 120 from the area of the second peak, the remainder is 1060 elect.[2] The number of nearest oxygen neighbors to each oxygen can then be calculated

$$N = \frac{1060}{3 \times 8.33 \times 8.33} = 5.1.$$

Since each oxygen is common to two triangular groups, it should have 4 nearest oxygen neighbors which are members of the same triangular groups.

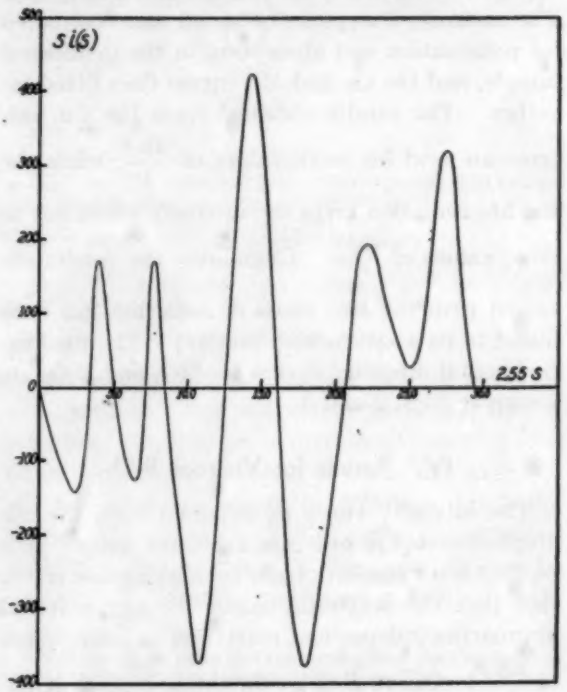

FIG. 4.—Curve *si*(*s*) for vitreous B_2O_3.

[4] (*a*) W. H. Zachariasen, "Structure of Calcium Metaborate (CaB_2O_4)," *Z. Krist.*, **83**, 354 (1932).
(*b*) W. H. Zachariasen, "Crystal Lattice of Boric Acid (BO_3H_3)," *ibid.*, **88** [2] 150–61 (1934); *Ceram. Abs.*, **13** [9] 242 (1934).

As seen on Fig. 5, the second peak is not well resolved on the right-hand side, and the difference between 5.1 and 4.0 is therefore probably due to the inclusion of other neighbors at slightly larger distance.

On the assumption that the bonds to an oxygen are roughly diametrically opposite, the next smallest distance will be the boron–second oxygen separation,

$$\text{B–O} = 1.39\sqrt{7} = 3.68A,$$

in good agreement with the observed peak at about $3.75A$. Interatomic distances greater than this value begin to depend markedly upon the relative orientations of the triangular groups with respect to one another, and the sharpness in the distribution curve rapidly fades out.

V. Results for Vitreous SiO_2

The radial distribution curve for vitreous SiO_2 is shown in Fig. 6. The first peak occurs at $1.62A$ in good agreement with the average silicon-oxygen distance, $1.60A$, found in various crystalline silicates.[5] From the values of f_{Si}/f_e and f_O/f_e, the best average value for the effective number of electrons per atom is found to be $K_{Si} = 16.0$, $K_O = 7.0$. The number of oxygens about each silicon is then calculated from the area of the first peak, 970 elect,[2]

$$n = \frac{970}{1 \times 16.0 \times 7.0 \times 2} = 4.3 \sim 4.$$

From the Fourier analysis we therefore get directly the fact that each silicon is surrounded by 4 oxygens at a distance of about $1.62A$. From the geometry of the tetrahedron, if $1.62A$ is the distance from corner to center, the distance from corner to corner will be

$$1.62\sqrt{\frac{8}{3}} = 2.65A.$$

The approximate position of the O–O peak at $2.65A$ proves that the four oxygens are arranged tetrahedrally about the silicon. The tetrahedral configuration in vitreous SiO_2 is therefore uniquely established by the first two peaks on the radial distribution curve.

Each silicon is tetrahedrally surrounded by 4 oxygens at a distance of about $1.62A$ and each oxygen is bonded between two silicons. Assuming that the two bonds to an oxygen are roughly diametrically opposite, the next few interatomic distances are readily calculated. These distances are indicated on Fig. 6 by a series of vertical lines, the heights of the lines being proportional to the expected peak areas. The oxygen–second oxygen distance depends upon the relative orientation of the tetrahedral groups, and the value $4.5A$ which is given represents only an average distance. The

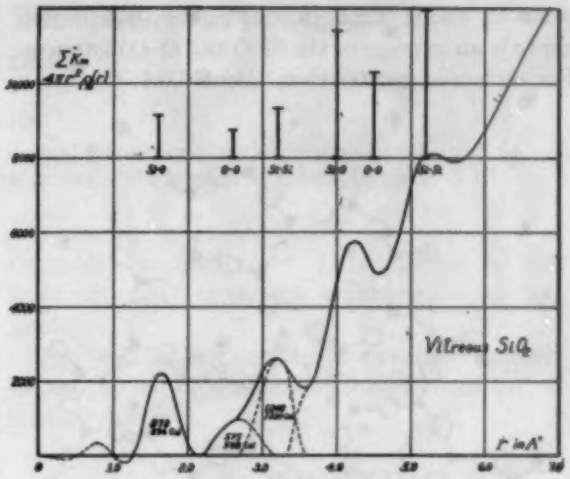

FIG. 6.—Radial distribution curve for vitreous SiO_2.

[5] W. L. Bragg, The Structure of Silicates. Acad. Publ. Soc., Leipzig, 1930; reviewed in *Z. Krist.*, **74**, 237 (1930); *Ceram. Abs.*, 10 [1] 73–75 (1931); *Jour. Soc. Glass Tech.*, **14**, 295–307 (1930).

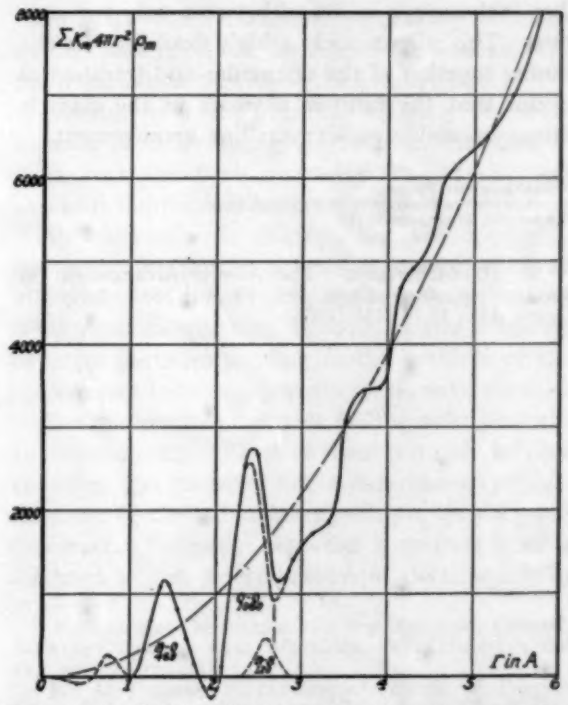

FIG. 5.—Radial distribution curve for vitreous B_2O_3.

peak at about 4.2*A* in the radial distribution curve is an average of the Si–O and O–O distances. For distances greater than about 6.0*A*, the inter-

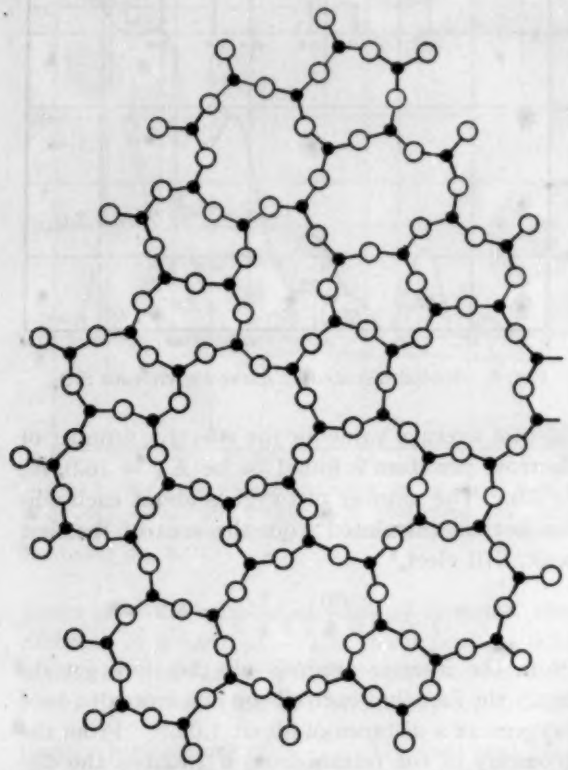

FIG. 7.—Schematic representation in two dimensions of the atomic arrangement in vitreous B_2O_3 (Zachariasen).

atomic separation depends upon the relative orientation of the tetrahedral units and the distribution curve rapidly smooths out.

VI. Discussion

By the method of Fourier analysis of the X-ray diffraction patterns, fairly definite and unique pictures have been obtained of the atomic arrangements in vitreous B_2O_3 and SiO_2. The results are in complete agreement with Zachariasen's predictions[6] concerning the structures of the oxide glasses. Figure 7 taken from Zachariasen's paper represents schematically in two dimensions exactly the structure of vitreous B_2O_3 which has been found from the Fourier analysis of the X-ray diffraction pattern. One has only to imagine the bonds in Fig. 7 as not being confined to the plane of the paper to build up the three dimensional random network of vitreous B_2O_3. The Fourier analysis of vitreous SiO_2 substantiates the results of the previous cruder X-ray studies on SiO_2 which have been made in this laboratory.

The remarkable glass-forming tendency of B_2O_3 and SiO_2 can be understood in terms of two features. First the triangular and tetrahedral coördination of the two cations demands that each oxygen shall be shared between two cations, and this results in the formation of complex aggregates in the melt. Since the atoms are already bound rather tightly in these complex aggregates, on rapid cooling there is not time for the atoms to disentangle themselves and get properly ordered for building up a regular crystalline structure. The second feature again involves the fact that each oxygen is shared between only two cations. This allows such a high flexibility in the joining together of the triangular and tetrahedral groups that the random network of the glass is almost as stable as a crystalline arrangement.

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[6] W. H. Zachariasen, "The Atomic Arrangement in Glass," *Jour. Amer. Chem. Soc.*, **54** [10] 3841–51 (1932); *Ceram. Abs.*, **12** [4] 145 (1933).

SIZE DETERMINATION WITH THE HAEMACYTOMETER*

By C. R. Amberg

Abstract

The article describes a quick microscope method for determining the average particle size of ground materials under 200-mesh in size. The method is an adaptation of the blood-count cell or haemacytometer.

I. Introduction

With the advance in ceramic technology, interest is being focused in many cases upon the finer particle sizes. Control of size is necessary if results are to be reproduced.

There are essentially four different methods of size determination in the size range under 200-mesh, namely, a screen method, elutriation with water, elutriation with air, and microscopic methods.

The usual screen method involves the screening of the material, *e.g.*, through a 325-mesh screen and determining the percentage residue which is taken as an index of fineness. It has the advantage of being quick and is a fairly satisfactory control test when run with the same screen and on material ground in the same manner every time. The allowable variation in opening for a 325-mesh screen is 90%, so that the use of different screens may introduce error and the test fails completely when materials ground by different methods are involved, for it gives no indication of the distribution of sizes or the average size.

Elutriation with water is a fairly accurate method of determining size and distribution of sizes, but the time necessary to run the test makes it impractical for most purposes.

Air elutriation is quicker, but the apparatus necessary for proper control is rather involved and time-consuming. The results, also, are somewhat open to question, because of the tendency of small particles to cling to the surfaces of the larger ones and consequently settle with them.

The microscopic methods for the most part are time-consuming. Most of them not only involve counting the particles but a simultaneous measurement of their diameters with an eyepiece micrometer. Fabianic[1] reported a method that is adapted to the determination of particle size in refractory manufacture. This method is not, however, suited to the fine grain sizes under 200-mesh.

The method proposed by the author is merely an adaptation of the familiar blood-count cell or haemacytometer.

II. Method

The standard haemacytometer consists of a cell, 0.1 millimeter deep and 1 millimeter square. It is ruled into tiny squares of $^1/_{400}$-square millimeter area. There are two such cells on the haemacytometer. It may be purchased from any supply house dealing in scientific apparatus.

A quantity of the material for size determination is weighed on a chemical balance and transferred to a graduate. A viscous liquid is added until a definite volume of solid plus liquid is obtained. The weight and volume are subject to individual preference, but 0.1 to 0.2 gram of ground material with enough liquid to make 10 cubic centimeters is ordinarily satisfactory for 200-mesh material. The liquid should be viscous to prevent rapid settling of the particles after being stirred and should be soluble so that it can be washed off by placing the cell under the tap. Glycerine or corn syrup is satisfactory.

Thorough stirring can be readily accomplished by blowing into the suspension with a glass tube. When a uniform suspension has been produced, a drop is removed on the glass stirring tube, and the suspension is allowed to creep under the cover glass of the cell by capillarity. It is important that the sample be introduced in this fashion to avoid erroneous results. Placing a drop on the cell and then laying on the cover glass will usually lead to a higher than normal particle count.

The cell is then allowed to rest for about 30 minutes to permit all particles to settle to the bottom of the cell. This is not absolutely necessary, but it is convenient because it avoids having to change focus constantly during the counting. A 4-millimeter objective is used, preferably one of the newer types with the longer working range.

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (Materials and Equipment Division).

[1] W. L. Fabianic, "Microscopic Control of Particle Size in Refractory Manufacture," *Jour. Amer. Ceram. Soc.*, 14 [1] 23–25 (1935).

A mechanical stage is also convenient but not necessary.

It is not necessary to count the total number of particles in the entire cell. Enough of the cell is counted to give 500 to 600 particles and the volume of suspension involved is determined by the number of the $^1/_{400}$-square millimeter areas counted. It is well to count a portion of the total from each of the two cells of the haemacytometer. The number of particles in a known volume of suspension is thus determined; the number of particles in the original weight of material taken can then be calculated, and the average weight per particle secured. The volume of a particle of average weight can be secured by dividing the weight by the specific gravity of the material and then calculating the diameter.

Assuming the particles to be spherical, the above operations can be combined in the formula,

$$d = \sqrt[3]{\frac{6wV_2}{\pi G V_1 n}}.$$

Where d = average diameter (cm.).
w = original weight of solid (grams).
V_2 = volume in cc. of the suspension counted.
G = specific gravity of the solid.
V_1 = total volume of suspension (cc.).
n = number of particles counted.

III. Results and Discussion

The average diameter determined by this method in all cases is less than the average diameter determined by screens or by elutriation and Stokes' law. This is to be expected since, either by screens or elutriation, the material is sized between two limits, and the average diameter is assumed to be the mean of the two limiting diameters. This is, of course, not the true situation. The weight of particles greater than the mean may be about equal to the weight of those less than the mean; but because of the smaller diameter, there is a far greater number of particles in the fraction less than the mean. The average diameter should, therefore, be less than the mean. Table I shows the comparison of average diameters as calculated from screen data or by Stokes' law from elutriation data with the average diameters determined by the haemacytometer method.

TABLE I

AVERAGE DIAMETERS

		Mm.
Wet-screened		
200–325-mesh	from screens	0.0558
	from haemacytometer	.044
Elutriated		
Fraction 1	Stokes' law	0.024
	haemacytometer	.023
Fraction 2	Stokes' law	.016
	haemacytometer	.014
Fraction 3	Stokes' law	.009
	haemacytometer	.007
Commercial 200-mesh quartz flint		
Elutriation and Stokes' law		.0082
Haemacytometer		.0059
Minus 200 Roll-crushed quartzite	haemacytometer	.0077

The average diameter does not, of course, express the size distribution directly, but the smaller the average diameter the greater is the proportion of fines. The comparison of the average diameter of commercial 200-mesh flint with that of roll-crushed quartzite, which passes a 200-mesh screen, illustrates this point.

The average diameter constitutes a convenient index for fineness which can be easily determined in one and one-half hours by anyone who can look through a microscope and count.

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II. STERILIZATION EFFECTS ON PROPERTIES OF CLAYS*

By Donald R. Baker† and Dudley P. Glick‡

Abstract

Five clays were prepared in duplicate series. One series of each was sterilized. Samples of the sterile and raw series were aged at 40°F and at 85°F. All samples were subjected to physical tests intended to determine plasticity before aging and after three subsequent aging periods. The effects of sterilization and temperature of aging upon the different clays are noted.

I. Introduction

In many industries it is common practice to age the clay for traditional periods of time with the value received evidenced only by a more workable clay and less cracking in the dried and fired state. If the change in the clay or factors causing the change were definitely known, conditions of the aging cellar could be adjusted to produce the same result in a reduced aging period.

By the comparison of the properties of sterilized clays with the properties of natural clays, it should be indicated (*a*) whether the improved properties gained by aging result from the growth of living organisms, (*b*) the length of time necessary for development of maximum working properties, and (*c*) the best temperature for the growth of organisms during aging.

II. Procedure

Four clays, selected for their extensive use in the ceramic industry and for their varied geological history, used in this study were as follows:

Series	Clay	Manufacturer
A	Kentucky ball clay No. 4	Kentucky-Tenn. Clay Co., Mayfield, Ky.
B	Georgia kaolin (crude)	Golding Sons Co., Butler, Ga.
C	North Carolina kaolin	Harris Clay Co., Spruce Pine, N. C.
D	Lower Kittanning plastic fire clay	Morgan and Horton, Eifort, Ohio
E	Earthenware body	

Composition	(%)
Feldspar	15
Ball clay	15
Kaolin (primary)	20
Kaolin (secondary)	15
Flint	35

(A) The ball clay is one of the strongest of the ball-clay group and is extensively used for the bond in a body; (B) the Georgia kaolin is an unwashed secondary clay; (C) the North Carolina kaolin is a washed primary or residual clay; (D) the fire clay selected is of the plastic group used in the refractories industry as the bond for flint clay; and (E) the body was selected to employ the above raw clays and to represent normal aging procedure.

The clays were ground through a 20-mesh screen, tap water added, pugged, and thoroughly wedged. The batch was divided into two equal parts, one to be aged naturally and the other to be aged after sterilization.

For the purpose of sterilization, a physical method was employed rather than a chemical one to prevent, as far as possible, changes in the clay due to the sterilization process. Steam under pressure of 15 to 20 pounds, corresponding to temperatures of 120° to 123°C, was applied for one hour in a horizontal autoclave. It was realized that the autoclave treatment might affect the properties of the clay other than the killing of living organisms. The temperature attained is above that at which most of the hygroscopic water is evaporated (110°C), but the atmosphere in the autoclave is saturated with steam. There may be more thorough penetration of moisture owing to the pressure in this treatment. The results after the initial change, however, are more important to this study. That this method was positive in destroying microörganisms was determined by subsequent bacteriological examination.

The clays were placed into 1000-cubic centimeter, wide-mouth bottles to provide a convenient means of retaining the samples in a sterile condition and to observe the appearance of the clay without danger of contamination. A cotton plug was inserted in the mouths of the bottles to provide a filter against contamination, and paper was placed over the plug to prevent the wetting of the cotton during sterilization. The samples were then autoclaved and withdrawn after cooling.

The periods selected for aging, after which

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the clays were to be tested were, immediately after sterilization, one week, four weeks, and eight weeks. The temperatures of aging were 40° and 85°F. The lower temperature was secured in a cold-storage room and the higher temperature in a room maintained at 85°F ± 3°F. The atmosphere was saturated under both conditions of aging by placing wetted sacks around the bottles.

After each aging period one bottle of each clay of the natural and sterile groups (ten bottles) was taken from the place of aging, and the clays were tested to determine their properties at that time.

After the longest aging period, eight weeks, the sterilized clays were examined bacteriologically and were found to have remained sterile.

III. Testing

The selection of tests to be employed in this study was especially difficult. The ordinary method of measuring workability of clay is the "feel" of the clay, but even then much experience is necessary to detect small differences. The Atterberg tests were used to measure the plastic range of the clay. *Lower liquid limit:* To a known weight of dry clay, water was added until the mass when cleft with a small V-shaped cut would just flow together and make an adhesional contact of the two portions when the containing dish was hit three slightly jarring blows. The percentage of water required to produce this plasticity was called the "lower liquid limit." *Lower plastic limit:* To a portion of the same dry clay water was added and mixed until it was plastic enough to roll into a thread under the hand on a dry smooth surface. It should be capable of being rolled into a thread $^1/_{10}$ to $^1/_8$ inch in diameter. It was rolled until the excess water was evaporated sufficiently so that the roll began to break into short lengths. At this point the water content was determined. The percentage of water indicates the lower plastic limit. The plastic range is the difference between the two limits and is called the "plastic index."

From each sample of clay after each aging period, three bars, $^1/_2$ inch square in cross-section and 4 inches long, were formed in a bar mold. They were thoroughly dried and the transverse strength was obtained. The modulus of rupture was calculated by the formula,

$$M = \frac{3Pl}{2bd^2}$$

Where M = modulus of rupture (lb./sq. in.)
P = breaking load (lb.)
l = distance between knife edges (3 in.)
b = breadth of bar (in.)
d = depth of bar (in.)

It was realized that three bars were insufficient to give satisfactory results if wide variations occurred among the replicates, but particular care was taken to produce a uniform bar and in the selection of equipment used for this test. The transverse strength may be regarded as a check on the Atterberg results.[1] It was impractical to make more or longer bars owing to limitations imposed upon the size of the clay batches by the sterilization process.

The dry shrinkage of the bars was calculated from the equation,

$$\frac{\text{Wet length} - \text{dry length}}{\text{Dry length}} \times 100 = \text{shrinkage (\%)}.$$

The water of plasticity was obtained on the clay when molded into bars, but the results represent only the amount of water present at the point of maximum workability determined by the feel of the clay.

Other tests, such as rate of settling, viscosity, and slaking, proved unsatisfactory in the preliminary tests in that they failed to measure the small differences which resulted from sterilization and temperatures and period of aging.

IV. Apparatus

The clay bars were formed in a wooden bar-mold with an opening $^1/_2$ inch square in cross-section and 4 inches long. An automatically controlled oven was used to dry the bars after forming.

To measure the cross-breaking strength, a special piece of equipment was made. From preliminary tests it was found that by using a direct-loading device the load required to break the small fragile bars would not exceed ten pounds. The clay bars were placed on rests lodged in V-shaped grooves at a 3-inch span. A wire stirrup was suspended at the center of the bar and a small tin bucket for receiving the load was supported from a hook on the stirrup. Water was allowed to run from a container above the apparatus

[1] A subsequent study has developed an important exception to this statement.

TABLE I

Sample*	T°F	Atterberg Plastic Index (Time of aging)				Dry Transverse Strength (lb./sq. in.) (Time of aging)				Dry Shrinkage (%) (Time of aging)				Water of Plasticity (%) (Time of aging)			
		Unaged	1 week	4 weeks	8 weeks	Unaged	1 week	4 weeks	8 weeks	Unaged	1 week	4 weeks	8 weeks	Unaged	1 week	4 weeks	8 weeks
A (*n*)	40	32.9	34.7	37.2	36.4	261	301	286	299	7.2	8.0	8.5	8.0	44.3	41.0	38.3	40.4
	85		35.6	38.1	38.3		269	293	326		8.0	8.5	8.5		48.8	36.5	41.3
A (*s*)	40	30.9	30.9	32.3	34.2	248	242	276	285	6.0	6.0	6.0	6.5	39.4	38.7	39.3	39.8
	85		30.7	32.6	34.0		252	289	280		6.0	7.2	6.5		38.0	40.3	38.2
B (*n*)	40	23.3	22.0	26.9	26.4	68	65	102	89	5.0	5.0	5.0	5.0	48.1	39.0	42.0	46.1
	85		26.5	28.0	28.6		79	94	108		5.0	5.0	5.2		39.2	41.0	43.2
B (*s*)	40	20.2	20.0	22.0	23.9	41	60	88	96	3.7	4.0	5.0	5.0	42.2	38.7	40.2	41.1
	85		20.8	21.9	24.2		54	92	101		3.1	4.0	5.0		39.1	44.1	40.3
C (*n*)	40	30.1	30.6	33.7	34.6	42	54	...	78	5.1	6.1	4.7	5.0	49.6	38.1	40.6	43.6
	85		32.0	34.8	34.3		44	82	90		4.0	5.2	6.1		46.5	43.2	42.8
C (*s*)	40	30.3	29.8	31.5	33.4	35	77	82	105	3.1	3.1	3.7	4.0	42.3	37.7	40.1	39.3
	85		30.5	31.8	33.6		38	54	86		3.1	4.9	4.7		37.1	42.0	41.8
D (*n*)	40	16.6	16.5	18.1	19.2	165	173	183	168	4.1	4.0	4.0	4.3	23.5	17.9	20.1	21.6
	85		17.1	18.6	18.8		181	190	203		5.0	5.0	5.1		21.7	22.3	23.0
D (*s*)	40	16.4	16.5	18.6	18.3	182	159	163	151	5.0	5.1	5.1	5.0	20.1	20.6	21.3	19.6
	85		16.4	18.0	18.5		152	170	168		5.2	5.6	5.0		19.3	20.2	19.3
E (*n*)	40	28.2	30.0	32.5	33.9	159	165	215	252	3.7	4.0	3.7	4.0	40.3	37.9	40.2	40.5
	85		31.7	33.0	34.1		182	210	291		5.0	5.0	5.2		30.8	38.6	39.3
E (*s*)	40	25.5	25.0	29.6	31.8	143	161	187	199	3.1	3.7	4.0	3.7	31.0	26.0	28.0	30.3
	85		26.0	29.5	32.3		165	193	203		3.1	4.0	4.3		26.0	27.3	29.8

* A, Kentucky ball clay; B, Georgia kaolin; C, North Carolina kaolin; D, plastic fire clay; E, prepared body; (*n*) aged naturally; (*s*) aged after sterilization.

through a rubber tube and into the bucket until the bar was broken; the water was then stopped by a pinch-cock on the rubber tube near the bucket. The load, which is a function of the water required to break the bar, was then weighed on a balance. The depth and breadth of the test piece at the fracture was measured to the nearest $^1/_{64}$ inch.

V. Discussion

Of the tests selected, the Atterberg plastic index proved the most successful in measuring the differences existing among the clays; it can be assumed that plasticity varies as the range in water content of the workable body, the more plastic clays possessing the greater range.

From the data above it will be seen that the most marked increase (5.9%) occurred in the unsterilized ball clay aged at a temperature of 85°F. The plastic body was next with the plastic index increased by 5.4%; following in diminishing order were the secondary kaolin, primary kaolin, and the plastic fire clay. It may be further observed that there were relatively small changes due to aging after one month. Comparing the sterilized clays with the natural clays, the final range of the sterilized clays after two months' aging is only slightly above the range obtained by aging the natural clay for one week. The sterilized clays increased their range in smaller proportions than the natural clays. It would also appear that there is little if any difference in aging a sterile clay at 40°F or 85°F, while that difference is marked in aging natural clay.

The immediate effects of sterilization differed among the clays. Very little change was noticeable in the appearance and workability of the plastic fire clay before and after sterilization and after aging; testing indicated a slight change. The ball clay was seriously affected by the sterilization. It became relatively dead, greasy rather than sticky, lighter in color, and lacked the ability to reunite while being worked for testing. Likewise, similar changes were noted in the ceramic body, the secondary kaolin, and the primary kaolin, with the least change in the plastic fire clay.

The dry transverse strengths indicated, in general, the same changes as the Atterberg tests. The natural ball clay gave the highest result after aging for two months at 85°F. The ceramic body stood next. Two months aging did not produce appreciable improvement in the fire clay. The values for the secondary kaolin and primary kaolin were low; the aging produced more improvement in the secondary kaolin. The strengths of the sterilized clays are generally lower than the natural clays, but differences are less prominent than in the Atterberg results. The values of the sterile clays at 40°F and 85°F are approximately the same.

The dry-shrinkage data yield little information. It was observed that in all naturally aged clays the shrinkage was greatest after aging for two months. In general, the sterile clays displayed less shrinkage than the natural clays.

VI. Conclusions

Living organisms are contributing factors to the aging of clays.

Other influences are at work during aging that tend to increase the workability of clays.

A temperature of approximately 85°F is more favorable than 40°F for the development of the plastic properties derived from the action of living organisms.

The workability derived from causes other than microörganisms is little affected by temperature.

Up to one month, the properties of clays are improved almost proportionately with time of aging; the clays continue to improve but at a lower rate.

The action of microörganisms affected the properties of the clays studied in diminishing order as follows: ball clay, earthenware body, secondary kaolin, primary kaolin, and plastic fire clay.

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CERAMIC ABSTRACTS

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Abrasives

Grinders, finishers of precision. André Nussbaumer. *Rev. mat. constr. trav. pub.*, No. 317, pp. 19–21B; No. 318, pp. 38–41B (1936).—Problems of structure and operation of grinders are dealt with, and the most efficient mechanism for grinders is explained. M.V.C.

Industrial diamonds and their uses. M. L. Van Moppes. *Sands, Clays & Minerals*, 2 [4] 121–31 (1936).—The employment of diamonds in various industries, their origin and preparation, tools to hold them, and shaping of the diamonds for different working purposes are fully described. M.H.

BULLETIN

Corundum in the Union of South Africa. W. Kupferburger. *Union of S. Africa, Dept. of Mines, Geol. Series, Bull.* No. 6, 81 pp. (1935). A.H.E.

PATENTS

Abrading or cutting apparatus. F. H. Johnston and A. R. Lambert (Ohio Units, Inc.). U. S. 2,037,796, April 21, 1936 (March 29, 1933).

Abrasive element and method of making. W. J. Ellis (Hazel J. Ellis). U. S. 2,038,782, April 28, 1936 (May 16, 1931; renewed Nov. 7, 1935). A method of making abrasive elements comprises forming a mandrel and permanently uniting an abrasive covering thereto in one continuous operation and then molding it under pressure.

Buffing or polishing wheel. W. W. Wells. Brit. 445,091, April 16, 1936 (Oct. 22, 1935).

Cutting off grinding wheel and method of making. Norton Co. Brit. 446,037, May 6, 1936 (March 5, 1934).

Cylinder grinder. Michael Kaminsky. U. S. 2,038,295, April 21, 1936 (Dec. 17, 1934).

Engine cylinder grinding machine. Joseph Sunnen. U. S. 2,040,281, May 12, 1936 (Aug. 22, 1935).

Gear grinding machine. E. W. Miller (Fellows Gear Shaper Co.). U. S. 2,038,665, April 28, 1936 (March 1 1932).

Grinding or abrading machine. Luke & Spencer, Ltd., and H. Critchley. Brit. 445,621, April 29, 1936 (Oct. 17, 1934).

Grinding or abrading tools. Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler. Brit. 445,512, April 29, 1936 (Aug. 20, 1934).

Grinding machine. H. E. Pruitt, U. S. 2,040,709, May 12, 1936 (Dec. 1, 1934). C. C. Stevens (General Motors Corp.), U. S. 2,040,449, May 12, 1936 (June 10, 1931; renewed Dec. 1, 1933).

Grinding machine and method. Sol Einstein (Heald Machine Co.). U. S. 2,039,711, May 5, 1936 (Oct. 26, 1931).

Grinding wheel. H. D. Geyer (General Motors Corp.). U. S. 2,038,727, April 28, 1936 (June 20, 1935). A grinding wheel of nonmetallic abrasive material has a metal support therefor surface bonded thereto over substantially the entire radial surface on one side of the wheel by means of an intervening metal layer which adheres strongly to both the abrasive material and the metal support.

Lapping method and apparatus. H. E. Snyder (Clarence I. McAllister). U. S. 2,039,852, May 5, 1936 (Dec. 8, 1933).

Machines for grinding gear wheels. Gear Grinding Co., Ltd., and A. H. Orcutt. Brit. 445,048, April 16, 1936 (Oct. 17, 1935).

Magazine grinder. C. A. Waterous. U. S. 2,039,572, May 5, 1936 (June 29, 1933).

Method and apparatus for testing grinding wheels, etc. H. R. Simonds (Simonds Worden White Co.). U. S. 2,039,563, May 5, 1936 (May 20, 1935).

Polishing roll. R. K. Brooks (Charles W. House & Sons). U. S. 2,039,677, May 5, 1936 (Nov. 12, 1934).

Polishing wheel. E. B. A. BLOUNT. U. S. 2,039,578, May 5, 1936 (April 20, 1935).

Razor blade sharpener. A. J. DREMEL. U. S. 2,039,150, April 28, 1936 (Dec. 30, 1932).

Tool for dressing grinding wheels. F. E. KOEBEL. Brit. 445,925, May 6, 1936 (Nov. 1, 1935).

Art and Archeology

Antique china and glass at New England tavern. ANON. *China, Glass & Lamps*, **52** [5] 45–48 (1933).—The Old Tavern in Northampton, Mass., contains a fine collection of antique china and glass, principally early American and English. Illustrated. G.M.P.

Belleek, the only Irish porcelain. ANON. *China, Glass, & Lamps*, **52** [9] 27–29 (1933).—This ware is characterized by egg-shell thinness and mother-of-pearl sheen. Intricate pieces were also woven by hand with threads of porcelain. Illustrated. G.M.P.

Decorative development in American dinnerware. ANON. *China, Glass & Lamps*, **54** [4] 63–66 (1934).—The major factories are developing distinctive styles. Decalcomania as a whole is making no marked advance. The use of underglaze processes is increasing. G.M.P.

Delft. ANON. *China, Glass & Lamps*, **53** [6] 8 (1934).—The term, delft, is usually associated with delft blue. Early delftware had elaborate decorations. During the period 1650 to 1710 it was done in an oriental style in blue, red, green, yellow, and gold. From 1710 till its decline it was a more commercial type. G.M.P.

Delft from Holland. ANON. *China, Glass & Lamps*, **54** [4] 58–59 (1934).—Pottery from this 370-year old factory is still available. Every year the factory reproduces one piece of fine pottery from some period in delft history. Illustrated. G.M.P.

Dinnerware style and decoration. F. H. RHEAD. *Crockery & Glass Jour.*, **118** [1] 41 (1936); *Pottery, Glass, & Brass Salesman*, **51** [23] 45 (1935).—R. states that a more concentrated effort should be made to support decorative research and creative development. M.C.S.

Four centuries of dining. ANON. *China, Glass & Lamps*, **52** [8] 19–21 (1933).—There is a similarity, *e.g.*, in the shape of plates and goblets, between table settings of the 1600's and the ultra-modern, though different materials are used. G.M.P.

Metallic lusters. ANON. *Chem. Trade Jour.*, **96** [2490] 89–90 (1935).—Luster preparations consist of metallic organic compounds or of colloidal metallic suspensions in a suitable medium. Modern lusters are divided into colorless, colored, and mixed. Colorless metals are Pb, Ag, Bi, Al, Zn; colored metals are Fe, Ni, Co, Cr, Mn, Au, U, Pt; and suitable mixtures are Bi and Au, Pb and Cr, Bi and Fe, Zn and Cu, and Th, Sn, and V. A number of recipes is given. H.H.S.

New ideas from old designs. ANON. *China, Glass & Lamps*, **53** [10] 11 (1934).—Glass and pottery from medieval Italy is illustrated, showing as wide a range of taste as the glassmaker of today must meet. G.M.P.

Pink tower. ANON. *China, Glass & Lamps*, **52** [5] 49 (1933).—This pattern was one of the first used by Spode for underglaze printing. He used the gadroon edge which was copied from silver plates of the Georgian era; the landscape was sketched from Spode's estate. G.M.P.

Porcelain of the Cincinnati. ANON. *China, Glass & Lamps*, **54** [3] 35–38 (1934).—Many members of the Society of the Cincinnati, a society of Revolutionary War officers, had tableware decorated with the emblem of the organization. It was imported from various sources. Illustrated. G.M.P.

Portland vase. ANON. *China, Glass & Lamps*, **52** [12] 25 (1933).—The original Portland or Barberini vase of glass was discovered in a sepulchral chamber near Rome about 1625. It was copied in clay by Wedgwood in 1790. See "Wedgwood—" *Ceram. Abs.*, **11** [2] 76 (1932). G.M.P.

Pottery printing: the engraving. J. H. LATCHFORD. *Trans. Ceram. Soc.*, **34** [10] 417–20 (1935).—A brief history of pottery engraving and printing covering the last 180 years is presented. R.H.H.P., JR.

Pottery printing paper. B. J. BELL. *Trans. Ceram. Soc.*, **34** [10] 421–24 (1935).—Pottery printing tissue should be made entirely from rags and should possess great wet strength, absorbency, and uniformity in thickness; it should be free from fluff and have a reasonably white tint. R.H.H.P., JR.

Raw glazes containing boric acid for clayware with a lime and feldspar content. C. STÜRMER. *Sprechsaal*, **68** [52] 794–95 (1935).—Attempts to produce glazes for clayware with boric acid and to lower the additions of lead are described. Clay bodies with a high lime content are not suitable for raw glazes containing boric acid because the bodies absorb them extensively; this could not be avoided by changing the composition of the glaze. M.V.C.

Stone Age man in Persian Baluchistan. C. L. FABRI. *Asia*, **34**, 468–73 (1934).—A reconnaissance expedition found the remains of large towns built of mud brick, with Late Stone Age painted pottery and stone implements, which dated from B.C. 4000 to B.C. 1000. The civilization here was similar to that of Iraq and also of the Indus valley and was developed along a caravan route between these places. W.D.F.

What about underglaze? ANON. *China, Glass & Lamps*, **53** [12] 22–24 (1934).—The development of underglaze prints for decoration of dinnerware has been an important feature of the past year in dinnerware production. One reason was the lack of originality in decalcomania decoration. Illustrated. G.M.P.

Zwiesel glass. BRUNO MAUDER. *Sprechsaal*, **69** [1] 1–2 (1936).—The State Trade School at Zwiesel, Bavaria, is concerned with teaching the best methods of decoration of glass, whether cutting, engraving, or painting. The school, in close association with industry and handicraft, has achieved great success. The greatest part of the production of hollow glassware is decorated by hand. Illustrated. M.V.C.

BOOK

Chinese Ceramics under the Ts'ing Dynasty. J. VAN GOIDSENHOVEN, Brussels. Reviewed in *Verre & Silicates*

Ind., **7** [7] 86 (1936).—The long period from 1644 to 1912 in Chinese ceramics receives scholarly treatment. Numerous colored plates add to the interest and artistic value of this excellent work. M.V.C.

PATENTS

Designs for:

Bottle. E. W. Fuerst (Owens-Illinois Glass Co.), U. S. 99,350, April 21, 1936 (Feb. 28, 1936). A. I. Lorenzen (Owens-Illinois Glass Co.), U. S. 99,627 and 99,644, May 12, 1936 (March 20, 1936). W. H. Miller (Carr-Lowrey Glass Co.), U. S. 99,411, April 21, 1936 (Feb. 27, 1936). Frasier Smith (Hazel-Atlas Glass Co.), U. S. 99,374, April 21, 1936 (April 1, 1935). J. S. Steelman (Whitall Tatum Co.), U. S. 99,376, April 21, 1936 (Nov. 13, 1935).

Humidor. A. I. Lorenzen (Owens-Illinois Glass Co.). U. S. 99,577, May 12, 1936 (Jan. 3, 1936).

Packer jar. F. J. Petty (Ball Brothers Co.). U. S. 99,461, April 28, 1936 (March 2, 1936).

Sham pilsener tumbler. J. A. Hutchison (Central Glass Works). U. S. 99,508, May 5, 1936 (Nov. 15, 1935).

Decalcomania paper. John MacLaurin. U. S. 2,038,118, April 21, 1936 (Sept. 17, 1934).

Cements

Hydration of $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$. Y. Sanada. *Jour. Soc. Chem. Ind. Japan*, **39** [2] 46B (1936).—Brownmillerite reacts with water as follows: $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$ + water ⟶ $3CaO \cdot Al_2O_3 \cdot aq.$ + $CaO \cdot Fe_2O_3$ aq. Needle, hexagonal plate, and rhombic dodecahedron crystals were found. M.V.C.

Length variation of a cement body in relation to air moisture content. Maurice Lucas. *Compt. rend.*, **201** [1] 58–59 (1935).—It is known that the weight and length of a cement body depends on the hygrometric state of ambient air. The extent of this variation has been determined on a pure slag cement body, dried for 30 months, the shrinkage of which was practically fully accomplished. The length variation curve given in function of the relative humidity of the air is nearly a straight line in the practical interval and may be represented by the relation,

$$\Delta l = 12 \times 10^{-4} E,$$

if the value for E be between 0.15 and 1 (E is the hygrometric state of the air, expressed in fractions of unit). The rate of variation rapidly decreases as the air becomes drier. The variation between zero and 1 exceeds 2 mm./meter in some cases. R.W.D. + M.H.

Lime modulus, lime saturation, and lime standard for Portland cement. Hans Kühl. *Tonind.-Ztg.*, **59** [100] 1221–24 (1935).—The idea of the "lime standard" means that lime content which is combined by hydraulic factors at the sintering temperature according to chemical equilibriums. The equation is as follows: Lime standard $= \frac{100}{2.8\,SiO_2 + 1.18\,Al_2O_3 + 0.65\,Fe_2O_3}$. M.V.C.

Reactions between aluminous cement and water. G. Assarsson. *Sveriges geol. Unders.*, **27** [4] 22–60; abstracted in *Verre & Silicates Ind.*, **7** [7] 85 (1936).—The sequence of the formation of products of hydration is given. Aluminous cements are entirely hydrated in two days; Portland cements require months. See *Ceram. Abs.*, **14** [2] 31 (1935). M.V.C.

Special cement studies. Czernin. *Tonind.-Ztg.*, **59** [90] 1113–15; [91] 1127–29 (1935).—C. discusses papers on cement research read at the meeting of the Kaiser Wilhelm Institute for Silicate Studies, in Berlin in Oct., 1935. M.V.C.

BULLETIN

Annual Report of the Building Research Board for 1932. Department of Scientific and Industrial Research. Published by H. M. Stationery Office, London. Price 2s 6d net. The Report summarizes the researches of the Building Research Station on cement and concrete, including work on the constituent components of fresh and set cement, free lime in fresh cement, fineness and rate of hydration, crazing of concrete products, and the properties of pigments used in concrete. Studies are also being made on the strength development in mass concrete and the effect of maturing temperature on the strength of concrete and on the action of sea-water on concrete. A. P. Som

PATENT

Oxychloride cements. A. G. Bloxam (Tajmal, Ltd.). Brit. 445,613, April 29, 1936 (Oct. 5, 1934).

Enamel

Ammonium carbonate in enamel. Vielhaber. *Emailwaren-Ind.*, **12** [46] 369–70 (1935).—Ways in which ammonium carbonate may influence enamels and their properties when added to the enamel batch are discussed. M.V.C.

Antimony compounds as substitutes for tin oxide for white enamels and the hygienic rating of antimony-containing enamels. K. Beck. *Korrosion & Metallschutz*, **11**, 132–33 (June, 1935).—A lecture is summarized. Foodstuffs may attack an enamel containing antimony to give either a complex antimony organic compound or an ionizable inorganic compound. The ionized compounds are relatively harmless, pentavalent antimony being even less toxic than the trivalent form. Organic acids found in fruit juices, particularly citric acid, are likely to dissolve antimony. Antimony introduced as antimony trioxide appears to be more easily attacked than that introduced as sodium meta-antimonate. The test for attack is as follows: Heating for ½ hour in 3% tartaric acid should yield less than 3 mg. of trivalent antimony per liter of volume for hollow vessels, or per 5 sq. decimeters of surface for others. J.B.A.

Calculating the batch from the analysis. Anon. *Emailwaren-Ind.*, **12** [49] 395–96 (1935).—Examples are given. M.V.C.

Calculations in practice. Anon. *Emailwaren-Ind.*, **12**

[46] 372–73 (1934).—Ways to calculate (1) the elasticity modulus of an enamel and (2) the loss of firing are explained, and ratios of the loss on firing of a series of materials used in the composition of enamels are given. M.V.C.

Cast iron for vitreous enameling. J. W. GARDOM. *Foundry Trade Jour.*, **52** [982] 399 (1936).—The most suitable cast iron for enameling (1) has a smooth surface free from blemishes, (2) produces sound castings free from all traces of external unsoundness, (3) contains no occluded gases, (4) has a stable structure, *i.e.*, one composed of graphite and ferrite produced by annealing an iron of suitable composition, (5) has a silicon content sufficiently high to avoid the possibility of graphite entering into solution in the iron at the enameling temperature, and (6) contains the graphite in as fine a state of division as possible. Discussions are included. H.E.S.

Common salt in enamel. VIELHABER. *Emailwaren-Ind.*, **12** [46] 372 (1935).—A white powder enamel containing common salt is analyzed. M.V.C.

Copperheads and fishscales. VIELHABER. *Emailwaren-Ind.*, **12** [43] 347–49 (1935).—The origin of copperheads and fishscales is discussed according to the researches of Rosenberg (*Ceram. Abs.*, **15** [1] 11 (1936)). The lack of knowledge of the composition and properties of sheet iron and therefore the use of unsuitable enamel are reasons given for the appearance of these defects. M.V.C.

Defects in the enamel layer due to the sheet used. A. LEON AND A. SLATTENSCHECK. *Sprechsaal*, **69** [3] 31–33; [4] 46–51 (1936).—Pickling blisters and slag inclusion determined in the sheet iron were found to be the cause of defective spots in the enamel layer. These spots sooner or later produce a flaking of enamel particles. Deformed grains or particles were found in the blisters; this led to the conclusion that the defective spots originated during the production of the sheet iron, probably during its cold working. The repeated heating of the sheet iron causes an arching of the blisters, which produces strains and causes a flaking in the enamel. Illustrated. M.V.C.

Degreasing metallic pieces. ANON. *Rev. Email. Vernis. Nickel*, pp. 7–9 (Jan., 1936); abstracted in *Verre & Silicates Ind.*, **7** [6] 69 (1936).—Complete degreasing of metal pieces includes the following operations: (1) degreasing by solvent to dissolve the greater part of the grease, (2) pickling to remove oxides, and (3) degreasing in an electrolytic or nonelectrolytic alkaline bath. M.V.C.

Do we need new raw materials? VIELHABER. *Emailwaren-Ind.*, **12** [42] 339–40 (1935).—The use of native raw materials because of the difficulties in importing foreign raw materials into Germany is discussed. The use of synthetic cryolite is recommended. Alumina alone or in combination with fluorine is a good opacifier. Fluorine can be introduced as sodium fluosilicate or fluorspar; alumina, by feldspar, clay, and kaolin. It is better to use German feldspar than trachyte, pumice stone, or basalt. M.V.C.

Drying granules of powder enamel. VIELHABER. *Emailwaren-Ind.*, **12** [42] 340–41 (1935).—Methods used for drying enamel after grinding are briefly discussed. M.V.C.

Dull enamels. VIELHABER. *Emailwaren-Ind.*, **12** [44] 356–57 (1935).—It is easy to obtain wet enamels at the expense of luster by increasing the amount of opacifier, such as alumina or antimony, in the mill. When part of the ware is coated with mat enamel, these parts are corroded with hydrofluoric acid, sandblasted, or powdered with powder enamel and then fired. M.V.C.

Electric kilns in the enamel industry. E. FR. RUSS AND WERNER V. ASTEN. *Glashütte*, **65** [50] 783–85 (1935).—The cost of operation and performance of electric kilns and of those heated with coal are compared. See *Ceram. Abs.*, **13** [8] 200 (1934). M.V.C.

Enamel defects due to muffle gases. VIELHABER. *Emailwaren-Ind.*, **12** [41] 329–31 (1935).—Cases of the penetration of gases into muffles because of low draft or overcharging the furnace with fuel, and the development of gases by the enamel itself when in the muffle are discussed. The muffle atmosphere should be tested as to its carbon monoxide, carbon dioxide, and steam content. M.V.C.

Enameling with one coat. VIELHABER. *Emailwaren-Ind.*, **12** [51] 411–12 (1935).—The experiments of Porter and Bryant (*Bull. Amer. Ceram. Soc.*, **14** [11] 367–68 (1935)) are discussed. M.V.C.

Factors to increase production in enameling plants. B. B. KENT. *Foundry Trade Jour.*, **52** [973] 246–49 (1935).—The five most important factors controlling production in an enameling plant are (1) plant layout, (2) hiring the best operators, (3) efficient maintenance of staff, (4) cleanliness, and (5) correct lighting. K. discusses the smaller details upon which so much depends and which insure liaisons between the many operations in the complicated process of porcelain enameling. H.E.S.

Frit kilns and fritting. J. H. DAVIDSON. *Foundry Trade Jour.*, **52** [976] 299–302 (1935).—The purposes and objects of fritting are pointed out. The advantages and disadvantages of the various types of fritting furnaces are explained, *e.g.*, stationary frit kilns, semirotary furnaces, and rotary furnaces. A discussion is included. H.E.S.

German mineral raw materials for the enamel industry. VIELHABER. *Emailwaren-Ind.*, **13** [2] 13–15 (1936).—The use of feldspar in enamel and the possibility of replacing it by other minerals, such as basalt, granite, pumice stone, lime, etc., are discussed. The higher the alkali and alumina content and the lower the iron content, the more valuable these minerals are. M.V.C.

Local corrosion of iron and steel in dilute watery salt solutions. CARIUS. Read before "Corrosion Meeting," Berlin, Nov., 1935; abstracted in *Emailwaren-Ind.*, **12** [49] 396 (1935). M.V.C.

Mills and grinding operation. VIELHABER. *Emailwaren-Ind.*, **12** [42] 338–39 (1935).—Directions for correct grinding and its importance are briefly discussed. M.V.C.

Muffle atmosphere. VIELHABER. *Emailwaren-Ind.*, **12** [43] 345–47 (1935).—The researches of Ebright, McIntyre, and Irwin (*Jour. Amer. Ceram. Soc.*, **18** [10] 297–302 (1935)) on the effect of gases, especially steam, on the enamel in muffles is discussed. M.V.C.

Porcelain enameling. EDGAR SCHELLENBACK. *Clay Prod. News*, **9** [3] 9 (1936).—A historical sketch of the development of porcelain enameling is given. There is evidence that the application of glass to metals for decorative purposes was used 2000 years ago. Enamelware had no commercial value until about 1860. It was then first used

in the production of hollowware. Since that time the adoption of porcelain-enameled ware has steadily grown. M.C.S.

Practice of stove hearth enameling. H. LANG. *Glashütte*, **65** [52] 809–14 (1935).—A detailed description is given of the successive stages of enameling, such as selection of raw materials, grinding, enamel preparation, preparing the cast or sheet iron, firing, etc. M.V.C.

Sandblasting. K. HILL. *Foundry Trade Jour.*, **52** [961] 55–56 (1935).—The general requirements demanded in the sandblasting and cleaning of castings for vitreous enameling are pointed out. **Discussion.** J. T. GRAY *et al.* *Ibid.*, [963] 91–92 (1935). H.E.S.

Sand control in the steel foundry. A. V. LEUN. *Trans. Amer. Foundrymen's Assn.*, **40**, 273–88 (1932); abstracted in *Iron & Steel Ind.*, **6** [7] 243–47 (1933); see *Ceram. Abs.*, **12** [4] 144 (1933). E.H.McC.

Structure of cast iron and its relationship to corrosion. E. PIWOWARSKY. Read before "Corrosion Meeting," Berlin, Nov., 1935; abstracted in *Emailwaren-Ind.*, **12** [49] 396–97 (1935). M.V.C.

Use of inhibitors to prevent corrosion by acids. V. A. WARDELL. *Chem. Eng. Mining Rev.*, **27** [320] 286–90; [321] 321–23 (1935).—Addition agents for preservation of metals against corrosive liquids have a wide range. (1) The oldest and best known are glue, gelatine, and starch. (2) Modern organics include heterocyclic compounds of relatively high molecular weight, such as quinoline and its derivatives, sulfur compounds such as CS_2 derivatives, trithioformaldehyde, thioglycollic acid, thiourea derivatives, naphthalene sulfonic acid, sulfite pulp liquor, and tannin extracts. (3) As, Sb, $SnCl_2$, NaCl: tables are given showing "percentage inhibition," the attack on a metal under test conditions without inhibitor counting as 100% non-inhibition. Starch is a feeble inhibitor compared with glue. Equal to glue, or more effective, are acridine, methyl acridine, and the most efficient 3,6-dimethyl, 2,7-diethyl diamino acridine hydrochloride, which in a concentration of 0.33% has 99.8% inhibiting power. Weight for weight, As is more effective than any organic for protecting iron, but it accelerates the solution of Zn in HCl. The nature of the mechanism of inhibition is discussed; the evidence is that inhibitors are adsorbed at the protected surface. Certain inhibitors prevent general corrosion but tend to promote local corrosion at isolated points, with resultant pitting. H.H.S.

Using enamel chips. VIELHABER. *Emailwaren-Ind.*, **12** [52] 418–19 (1935).—Methods for reusing enamel splinters or chips composed of ground and cover enamel as a new ground enamel are discussed. M.V.C.

Wave formation in bathtub enamels. VIELHABER. *Emailwaren-Ind.*, **12** [48] 389–90 (1935).—A wavy appearance on the surface of bathtubs is often due to the powder enamel because it has had too short a temperature interval (temperature space between incipient softening and liquefying). This defect can be avoided by changing the enamel composition, replacing silica by ZrO_2 or TiO_2. The grinding fineness of the enamel should be determined by test, as too fine grinding shortens the temperature interval. M.V.C.

PATENTS

Lavatory basins and sinks. POUNTNEY & CO., LTD., AND F. LONGBOTTOM. Brit. 445,947, May 6, 1936 (Oct. 29, 1934).

Method of decorating enameled ware. W. B. MOORE (Moore Enameling & Mfg. Co.). U. S. 2,039,548, May 5, 1936 (May 11, 1935).

Method of enameling. W. G. MARTIN (A. O. Smith Corp.). U. S. 2,039,178, April 28, 1936 (May 18, 1934). In the manufacture of glass-lined tanks the steps comprise introducing air into the tank during the fusion of the enamel, to maintain within the tank a pressure in excess of the atmospheric pressure, and allowing air to escape from the tank to provide a passage of air therethrough.

Glass

Absorption of X-rays by lead glasses and lead-barium glasses. GEORGE SINGER. *Jour. Research Nat. Bur. Stand.*, **16** [3] 233–51 (1936).—The results of a study of the protective properties of a group of typical flint and barium-flint glasses are reported. In chemical composition, the protective glasses analyzed were found to resemble closely the denser optical flint and barium-flint glasses. The protection coefficients of the glasses were determined by an ionization method; of the various component elements, only lead and barium contribute appreciably to the protective effectiveness of the glasses. For flint glass, empirical relations were established between the protection coefficient and the chemical composition, density, and refractivity; for barium-flint glass an empirical relation is given between the protection coefficient and the lead oxide and barium oxide components of the glass. R.A.H.

Annealing glass in electrically heated furnaces. RUD. BUCHKREMER. *Sprechsaal*, **69** [1] 4–6 (1936).—The theory of annealing and the development of modern cooling furnaces are discussed. Principles of construction of electrically heated furnaces and the various zones within the furnace are discussed. Curves are given for the electrical power consumed for various times of annealing, weight of ware annealed, and the entering temperature of the glass. Details of double-walled furnaces (having nickel-chrome elements) are given. Illustrated. M.V.C.

Automatic pressure-testing machine for bottles. ANON. *Glass Ind.*, **17** [5] 173–74 (1936).—An automatic machine capable of testing ten siphon bottles per minute, each bottle at a precisely known steady pressure for a full minute period, is described. The machine consists essentially of twelve individual machines built into a compact unit, with provision for automatic sealing and application of pressure. Illustrated. E.J.V.

Course in glassmaking. D. R. *Verre & Silicates Ind.*, **7** [8] 93–95 (1936).—Exothermic and endothermic reactions and factors governing them in gas generators are discussed. See *Ceram. Abs.*, **15** [6] 175 (1936). M.V.C.

Cutting and tempering glass disks and grinding glass tubing ends. E. G. PICKELS. *Rev. Sci. Instruments*, **6** [7] 202 (1935).—Unusually strong disks which do not break into sharp splinters when shattered can be made from ordinary glass. A convenient circular cutter for forming and grinding the disks is described. The tempering is accom-

plished by slowly rotating the disk in an electric furnace just below the softening temperature of the glass and then quenching by dropping into heavy compressor oil at room temperature. H.E.S.

Dependence of the speed of reaction in a glass batch on the physical nature and chemical composition of the raw materials: I, Dependence of the speed of reaction in sand-soda mixtures on the grain size of sand. U. LINDE AND F. H. ZSCHACKE. *Glastech. Ber.*, **11** [12] 445–54 (1933).—(1) By determining the amount of soda remaining in the melt, the dependence of the rate of disintegration on the grain size of sand was studied in three soda-sand batches of the same composition heated under different conditions. (2) The rate of melting increases with a diminishing grain size, but is not proportional to fineness, *i.e.*, to the surface of sand grains. (3) With increased temperature this difference decreases and disappears at a sufficiently high temperature. (4) As long as the batch has not vitrified, the effect of thermal conductivity (insulating capacity) of the unmelted batch prevails over that of the grain surface. The coarser the grain, the looser is the packing and the greater the effect of insulation. (5) In a sintered batch, thermal conductivity becomes equal and the effect of the sand surface on the rate of disintegration becomes clearly potent. The finer the grain, the greater the surface and the more rapidly soda is disintegrated or the sand dissolved. (6) The last remnants of soda disintegrate slowly. (7) The large bubbles present in the melt gradually become smaller and more numerous with a decreasing soda content and increasing saturation of the melt with silica. This is caused by an increasing viscosity with a rising silica content and a slowing down of the speed of disintegration of the remaining soda. M.V.C.

II, Relative speed of melting of the glass blends with boric acid and borax. F. H. ZSCHACKE AND J. VARTANIAN. *Ibid.*, **13** [5] 155–63 (1935).—The speed of reaction and melting process in the glass mix is dependent on the chemical compounds of the raw materials. The speed of reaction of chemically equivalent glass mixtures made from (*a*) sand, soda, and boric acid and (*b*) sand, soda, and borax were studied at different temperatures and times of treatment, chemically and microscopically. The beginning of the reaction in both mixtures was below 500°C. Marked reaction began at 800°C and proceeded rapidly up to 1100°C. From this temperature up, further heating had no influence on the formation of the water-soluble condition of the melt. In the boric acid series the formation of insoluble borates was somewhat later and slower than the difficultly soluble alkali silicate. In the borax series the formation of insoluble boric acid compounds began at the same time as insoluble alkali compounds and proceeded parallel with them. The end-points of the chief reactions came together. G.R.S.

Dispersely-colored two-phase glasses. ERIK KNUDSEN. *Kolloid-Z.*, **69** [1] 35–43 (1934).—Exploratory experiments were performed by adding various reagents to a base glass containing 75 mol. SiO_2, 15 mol. Na_2O, 10 mol. CaO, and a clear yellow carbon glass. Calcium phosphate produced a transparent red glass, the turbidity of which was increased by the addition of calcium acid arsenate. Antimony and tin oxide additions and replacement of silica with titania, of lime with PbO, and of Na_2O with K_2O were studied. The system SiO_2 67 to 74, Na_2O 16 to 9, $Ca_3(PO_4)_2$ 5, and Sb_2O_3 1.8 gave colors from infra-red to ultra-violet. F.P.P.

Effect of alumina on the devitrification of some soda-lime glasses. WILLIAM HORAK AND D. E. SHARP. *Glass Ind.*, **17** [5] 162–64 (1936).—A test method developed consists of subjecting small, freshly fractured cubes of glass to a temperature of 800°C for varying periods of time and determining the time required for appearance of the first signs of devitrification visible to the unaided eye. Results show that the substitution of 1% Al_2O_3 for SiO_2, making total Al_2O_3 equal to 1.8%, doubles the time required to devitrify this particular glass at 800°C. The effect of Al_2O_3 on devitrification time is slightly more pronounced for glasses of lower lime and higher alkali content. In either series curves approximate a straight-line relation between the alumina content and devitrification time up to about 4% Al_2O_3. Beyond this point and up to 6.5% Al_2O_3, the effect becomes progressively less. E.J.V.

Effect of a cover glass in reflectance measurements. DEANE B. JUDD AND KASSON S. GIBSON. *Jour. Research Nat. Bur. Stand.*, **16** [3] 261–64 (1936).—For diffusing surfaces the use of a cover glass may result in an error of as much as 10% of the reflectance. The effect of the cover glass can not be easily calculated because it depends on the diffusing characteristics of the two samples being compared as well as on their reflectances. R.A.H.

Effect of the structure of raw materials. ANON. *Glashütte*, **65** [50] 779–80 (1935).—The effect of the size and nature of raw materials on the rate of melting of glass are discussed. Curves showing this effect are plotted. M.V.C.

Electric furnace for annealing in automatic manufacturing. G. DELACROIX. *Verre & Silicates Ind.*, **7** [7] 80 (1936).—With an output of 14 to 18 tons of bottles a day, the furnace constructed by the Soc. Fours et Fumisterie Industrielle, Paris, anneals the glass so perfectly in continuous operation that no tensions can be observed with a polariscope; current for heating is not consumed even in semiautomatic manufacture. M.V.C.

Electric radiator in glass. ANON. *Glaces & Verres*, **9** [46] 6–7 (1936).—In addition to its use as safety glass, tempered glass has several other applications. Electric radiators are manufactured with this material. The apparatus is a sheet of tempered glass fitted in a suitable decorative stand; the glass plate bears an electric resistance made out of aluminium beads coated with aluminium oxide, so that its resistivity is about 10 times that of pure aluminium. This winding aluminium ribbon, reproducing fancy designs, is connected with a 110- or 220-volt electric current, which heats the aluminium resistance and brings the glass plate up to 100°C; after about 10 min. the normal thermal régime is attained. A small luminous spot indicates that the radiator is in service. Decorative chimney screens of the 800 watt/hr. type, based on this principle, are to be manufactured on an industrial scale. R.W.D.

Electrical conductivity of fused glasses in the temperature interval 600 to 1400°. K. S. EVSTROP'EV. *Zhur. Fiz. Khim.*, **6** [4] 454–67 (1935).—Changes in electrical conductivity of several fused glasses in the temperature interval 600 to 1400°C were investigated and compared with

those for fused salts and glasses. Conductivity of fused salts changes exponentially with temperature. The electrical conductivity of the glasses investigated varied with their viscosity. $\eta \cdot x$ = constant (where η is viscosity) is to be replaced by $\eta \cdot x^n$ = constant, which is true for all liquid conductors of the second kind. P.B. & E.S.

Glass in building. R. A. MILLER. *Ind. Eng. Chem.*, **27** [11] 1291–93 (1935).—The manufacture of window, plate, structural, and protective glasses is briefly described. Illustrated. F.G.H.

Glass tile "gripper" solves building in glass problem. ANON. *Amer. Glass Rev.*, **55** [18] 14 (1936). M.C.S.

Glasses absorbing heat radiations. R. D. *Verre & Silicates Ind.*, **7** [7] 81 (1936).—Ordinary glass permits 80% of calorific radiations to pass through it, while heat-absorbing glasses, containing certain iron compounds, may permit as little as 20% (Calorex glass). These glasses are finding more frequent use in storage and refrigerator plants, homes, public buildings, and in tropical countries. Because they keep heat in as well as out, interior temperatures are kept more uniform. The U.S., England, and Germany are the principal producers. M.V.C.

Investigation of electric conductivity of glass-like borates of alkali metals. B. I. MARKIN AND R. L. MÜLLER. *Zhur. Fiz. Khim.*, **5** [9] 1262–71 (1935).—The electrical conductivity of glass-like systems, $Li_2O + B_2O_3$ and $K_2O + B_2O_3$, and of glasses $Rb_2O + B_2O_3$ and $Cs_2O + B_2O_3$ were investigated. The logarithms of the specific resistivities of alkaline glasses correspond to the known equation, $\log W = \frac{A}{T} + B$; deviations are found only in small concentrations of alkalis. At concentrations 1.5 to 2.5 mol. per liter, lithium and potassium glasses disclose the beginning of a considerable increase of molar conductivity following to its minimum value, especially in the potassium system. Borate glasses, rich in lithium and potassium, give the empirical factor $A\sqrt{m}$ = constant (m = concentration mol./liter) known in relation to the sodium system. A constancy of the value $B - \log m$ is also observed with these glasses. From the values of electrical conductivity that have been observed, it can be deduced that the order of mobilities of the ions, starting with the greatest, is Li, Na, K, and Rb. See "Electrical—" *Ceram. Abs.*, **14** [9] 212 (1935). P.B. & E.S.

Investigation of miners' lamp-glasses in relation to lighting efficiency. W. H. MCMILLAN. *Trans. Inst. Mining Engrs.*, **88** [3] 161–69 (1934).—Mean spherical candle power is but little affected by the different types of well-glass in common use. Directional intensity and therefore light distribution are considerably affected by the different types of well-glass used. A.H.E.

Jena glass for fifty years. E. BERGER. *Zeiss Nachr.*, **8**, 1–7 (1935).—A historical review is presented of the work of Abbé, Schott, and Zeiss, and the uniting of the Jena Glass Works with the Carl Zeiss Foundation. (See "Otto Schott," below.) L.E.T.

Manufacture of early incandescent lamp bulbs at Corning. GEORGE B. HOLLISTER. *Bull. Amer. Ceram. Soc.*, **15** [5] 194–95 (1936).

Measuring viscosity by Margules method. Selection of the temperature of reference. UNION DES VERRERIES MÉCANIQUES BELGES. *Verre & Silicates Ind.*, **6** [18] 334–36 (1935).—The method of Margules for determining the viscosity of liquids permits the measurement of viscosity with precision in an interval from 10^{-7} poises (measurement of viscosity of air) up to 10^{8} poises (measurement of viscosity of glass). The viscosity of liquids in certain intervals varies rapidly as a function of the $t°$. The error which can be introduced in the determination of viscosity by Margules' method by the lack of uniformity of $t°$ in the mix to be tested is shown. M.V.C.

Methods for determining the chemical durability of soda-lime glasses. O. G. BURCH. *Bull. Amer. Ceram. Soc.*, **15** [5] 175–81 (1936).

Modern metals in architecture and decoration. J. HIRIART. *Aciers spéciaux*, **10** [124] 403–16 (1935).—The application of modern corrosion-resisting metals, particularly in connection with glass, and the production of artistic effects are illustrated. M.H.

Old English Glass: No. 64, Optical glass. FRANCIS BUCKLEY. *Glass*, **12** [10] 427–28 (1935).—A historical review of spectacle glass, which was produced as early as 1660 in England, is given. Illustrated. For Nos. 62-63 see *Ceram. Abs.*, **15** [4] 118 (1936). M.C.S.

Old Sussex Glass. LEONARD E. BRADDICK. *Glass*, **12** [12] 509 (1935).—Sussex glass was produced prior to 1557 and was made from alkali obtained from burning bracken and from silica from a local sand. M.C.S.

Otto Schott: A tribute. ALEXANDER SILVERMAN. *Bull. Amer. Ceram. Soc.*, **15** [5] 169–75 (1936).

Reducing the iron content of sand. I. I. KITAIGORODSKIĬ AND L. S. LANDE. *Glass*, **13** [1] 81–117 (1936).—A résumé of various chemical reactions which are partially effective in removing iron from sands is given. The authors made tests to determine the effectiveness of eliminating iron (1) as ferric chloride by using gaseous chlorine, (2) as magnetic oxide by using carbon monoxide, (3) as ferric chloride by using sodium chloride with superheated steam, and (4) as ferric chloride by using calcium chloride with superheated steam. Tests were also conducted to determine the effectiveness of treating iron-contaminated clays with hydrochloric acid to form the ferric chloride and effect its removal. This treatment reduced the iron content 90%. None of these tests was totally effective in removing the iron. See *Ceram. Abs.*, **14** [11] 275 (1935). M.C.S.

Rock crystal. ANON. *China, Glass & Lamps*, **53** [7] 21 (1934).—Rock crystal is defined as flint glass. Today it signifies a good quality lead glass with a cut and polished pattern. G.M.P.

Sandwich glass: IV. ALEXANDER SILVERMAN. *Glass Ind.*, **17** [5] 167–71 (1936).—Various formulas for amber, yellow, green, and green-alabaster glasses from the notebooks of Kern and Fessenden are given and discussed. For Part III see *Ceram. Abs.*, **15** [6] 177 (1936). E.J.V.

Tempering glass; properties of stressed glass. ANDRÉ THURET. *Ceram. Verrerie Email.*, **2** [9] 387–90 (1934).—Glass acquires different properties according to the rate of cooling during the temperature intervals at which it passes from the viscous to the solid state. A study of the temperature conditions under which glass becomes stressed and an examination of the properties of stressed glass are given. M.V.C.

Theoretical investigation of electrical conductivity of

glasses. R. L. MÜLLER. *Zhur. Fiz. Khim.*, **6** [5] 612–31 (1935).—A trial of a theoretical investigation of electrical conductivity of glass-like borates of alkalis from the viewpoint of their intermediate position between crystals with an ion lattice and salt solutions was made. The applicability of the Frenkel theory of electrical conductivity is demonstrated, providing that Frenkel's correction for the thermal-electrical conductivity effect be taken into consideration. Assumptions of the association of polar molecules in glasses are made, and the influence of association on the electrical conductivity of glasses is considered. In the investigation of the boron and silicate glasses rich in polar saltlike molecules, the following regularity was observed: $Am^{\frac{1}{x}}$ = constant (where A = a coefficient in electrical conductivity formula, $\log W = \frac{A}{T} + B$, m = molecular concentration, x = a coefficient equal to about 2 for boron glasses and 4 for silicate glasses). An electrochemical classification of glasses is suggested. See also *Ceram. Abs.*, **15** [4] 118 (1936). P.B. & E.S.

The 200-inch telescope. G. E. HALE. *Sci. Amer.*, **154**, 236–40, 293 (1936).—H. treats of the inception of the Yerkes and Mt. Wilson observatories and the present construction of the 200-inch telescope. A satisfactory tube has been designed and several types of mounting are being tested. The special grinding and polishing machine has been constructed. An extra correction lens will be installed to give a wider field having sharp definition. Several places for observers are to be provided, one of which will be inside the telescope tube at the principal focus. A series of spectrographs and much other auxiliary apparatus will be furnished. One of the cameras for the spectrographs will have an f.36 lens. The space reached will be fifty times that reached by other telescopes. The research program will include work on the nature of the "expanding universe" and spectrographic studies of the stars. See "Astrophysical—" *Ceram. Abs.*, **15** [6] 174 (1936). W.D.F.

Ultra-violet test as an aid in the glass industry. JULIUS GRANT. *Glass*, **12** [12] 520–22 (1935).—The ultra-violet light test is useful in detecting chemical composition differences in glasses. Minute amounts of highly fluorescent materials impart a characteristic to the glass which is easily detected under the ultra-violet ray. Selenides or oxides of uranium, zirconium, or the alkaline earth metals in glasses are easily detected by this method. M.C.S.

Unbreakable projector lenses. JOH. FLÜGGE. *Glashütte*, **65** [47] 740–42 (1935).—Special heat-stable glasses of a suitable composition which increases tensile strength and lowers the coefficient of thermal expansion and the elasticity modulus are described. An increased silica and boric acid content and additions of zinc and magnesium with lower alkali content are recommended. The glass is chilled in cold water. The reasons for the shattering of lenses are briefly discussed, and a German patent dealing with the grinding and polishing of lens edges is mentioned. M.V.C.

Use for waste glass. EDITORIAL. *Indian Eng.*, **93** [6] 107 (1933).—George J. Ricketts, a London engineer, has discovered a method of utilizing waste glass for surfacing roads. By a special process, R. melts down and adds toughness to the waste glass. The glass is cast into practically indestructible blocks, 5 in. square by 2 in. thick, with special interlocking flanges so that they may be made into interlocking sets of almost any size. Serrating has overcome any tendency to skid. A.P.S.

BOOKS AND BULLETINS

Glass Factory Directory, 1936. ANON. Budget Publishing Company, Pittsburgh, Pa. 152 pp. Price $3.00. M. C. SHAW

New Raw Materials for the Glass Industry. M. A. SHESTAKOV. State Sci. Research Inst. Glass. State Pub. House Light Ind., Moscow, 1934. 100 pp. Price 1R 60k. Tests have been made to replace soda ash and alkalis by alkali-containing rocks and other substances, which in some cases may be used in batches for glass manufacture. The chief raw materials with which S. deals are trachytes, feldspars, pegmatites, nephelines, nepheline syenites, volcanic ashes, pumices, andesites, basalts, phenolites, obsidians, and by-products of the chemical industry such as chromic sulfates, bisulfate, sulfites, blast-furnace slags, etc. S. I. PERKAL

Soldering glass or porcelain to metal. D. J. MACNAUGHTAN AND E. S. HEDGES. *Bull. Internat. Tin Research and Development Council*, No. 2, 48 pp. (Sept., 1935).—Glass and porcelain can be joined to metal fittings by the following method: a glaze high in Pt or Au is fired on the glass or porcelain in an oxidizing atmosphere. The metal parts are "tinned" with tinman's solder, fitted to the glazed body, and fired at a temperature less than the melting point of pure tin. H.H.S.

Struggle with Waste in Glass Articles. I. S. SHUR. State Pub. House Light Ind., Moscow, 1935. 116 pp. Price 1R 60k. An outline of the origin and classification of defects in glass is presented. Typical defects are given, and glass manipulation, annealing, and treatment of glassware are discussed. The packing, storing, transportation, and uses of glassware are described, with a note on the control of glass manufacture. A 5-page table listing defects and their causes in the different stages of glass manufacture is appended. S. I. PERKAL

PATENTS

Apparatus for cutting flat glass. JOSEPH GASKELL AND J. B. WATT (Pilkington Brothers, Ltd.). U. S. 2,039,402, May 5, 1936 (Dec. 23, 1933).

Apparatus for molding hollow bodies of glass. NEUE GLASINDUSTRIE-GES. Brit. 445,169, April 16, 1936 (Aug. 7, 1934).

Apparatus for transporting sheets of glass. EDMOND LAVERDISSE (Glaceries de la Sambre, Soc. Anon.). U. S. 2,038,662, April 28, 1936 (June 25, 1934).

Barium crown glass. FREDERICK GELSTHARP (Pittsburgh Plate Glass Co.). U. S. 2,038,726, April 28, 1936 (Feb. 19, 1934). A barium crown optical glass which would normally be subject to tarnishing contains sufficient tin oxide to render the glass resistant to tarnishing.

Bifocal and multifocal lenses. E. POLACKOFF. Brit. 445,083, April 16, 1936 (Aug. 20, 1935).

Composite safety glasses. SOC. DU VERRE TRIPLEX. Brit. 445,674, April 29, 1936 (Sept. 7, 1934).

Feeder. W. A. MORTON. U. S. 2,038,190, April 21, 1936 (June 24, 1929).

Glass annealing nesting rack. LOUIS POGLEIN (McKee Glass Co.). U. S. 2,039,927, May 5, 1936 (Nov. 25, 1935).

Glass edging machine. K. A. WEBER. U. S. 2,038,150, April 21, 1936 (Jan. 27, 1934).

Glass-feeding apparatus. W. T. HONISS (Hartford-Empire Co.). U. S. 2,040,789, May 12, 1936 (Dec. 15, 1934).

Glass-feeding method and apparatus. W. T. HONISS (Hartford-Empire Co.). U. S. 2,039,242, April 28, 1936 (Sept. 17, 1932).

Glass furnace. GARLAND LUFKIN (Owens-Illinois Glass Co.). U. S. 2,038,797, April 28, 1936 (April 16, 1934).

Glass gathering and molding apparatus. L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 2,038,808, April 28, 1936 (Aug. 15, 1933).

Glass polishing machine. J. J. WANKO. U. S. 2,040,720, May 12, 1936 (Dec. 28, 1934).

Glass resistant to alkali metal vapors and method of making. W. C. TAYLOR (Corning Glass Works). U. S. 2,038,691, April 28, 1936 (Nov. 6, 1934). The method of treating glass to make it resistant to discoloration by hot alkali metal vapors includes applying to the surface of the glass a fused-in coating of alkali fluoride and boric oxide.

Glassworking apparatus. W. W. EITEL (Heintz & Kaufman, Ltd.). U. S. 2,040,602, May 12, 1936 (April 17, 1934). In glassworking apparatus, a rotatable chuck comprising a plurality of relatively movable members adapted to frictionally engage and encircle a cylindrical glass blank having a single open end, means for securing the members against relative movement, means within the chuck for hermetically sealing the sides of the open end to the chuck, a mandrel axially mounted in the chuck for rotation therewith and adapted to support and position an element to be sealed to the closed end of the blank, the chuck being apertured to admit air under pressure to the interior of the blank through the open end, the mandrel being movable from without to facilitate the element seal without substantial loss of air pressure.

High electrical resistant soft glass composition. W. C. TAYLOR (Corning Glass Works). U. S. 2,038,690, April 28, 1936 (Feb. 7, 1934). The glass contains 55 to 60% SiO_2, 3 to 4% Na_2O, 8 to 10% K_2O, 19 to 21.5% PbO, 6.5 to 7.3% BaO, and 1.0 to 1.1% B_2O_3.

Instrument for detecting the presence of stresses in glassware. J. G. HOLMES AND J. ENGLISH. Brit. 445,212, April 22, 1936 (Nov. 21, 1934).

Leers for annealing glassware. O. MAETZ. Brit. 445,599, April 29, 1936 (Oct. 11, 1934).

Luminous gas discharge signs. R. HADDAN (Corning Glass Works). Brit. 445,168, April 16, 1936 (Aug. 2, 1935).

Machine for forming glass articles. R. H. BARNARD (Owens-Illinois Glass Co.). U. S. 2,038,519, April 28, 1936 (Dec. 31, 1934).

Manufacture of laminated glass. F. L. BISHOP. U. S. 2,040,238, May 12, 1936 (Feb. 25, 1933).

Mediums for cleaning and polishing glassware, etc. F. FATH. Brit. 445,880, May 6, 1936 (Oct. 19, 1934).

Method and apparatus for circulating molten glass. J. E. MCBURNEY (Owens-Illinois Glass Co.). U. S. 2,038,800, April 28, 1936 (April 19, 1934).

Method and apparatus for manufacturing hollow glassware. G. E. ROWE (Hartford-Empire Co.). U. S. 2,040,783, May 12, 1936 (Dec. 15, 1934).

Method and apparatus for melting glass. P. L. GEER (Amco, Inc.). U. S. 2,039,955, May 5, 1936 (June 9, 1932).

Method and apparatus for melting glass by electricity. DAVID STENHOUSE (Hazel-Atlas Glass Co.). U. S. 2,039,853, May 5, 1936 (Oct. 3, 1933).

Method of making glass. A. E. BADGER (Corning Glass Works). U. S. 2,038,627, April 28, 1936 (July 18, 1935). The method of making glass which is substantially free from bubbles includes fusing the batch therefor in the presence of helium so that the bubbles which remain in the fused glass and which would normally contain air and other gases, will instead contain substantially pure helium and maintaining the glass in fused condition until the helium has diffused out of the bubbles.

Method of manufacturing bulbs for electric incandescent lamps. JÉRÔME & BONNEFOY & CIE, AND LAMPE YVEL, AUTO LAMPE & CIE, ANCIENS ÉTABLISSEMENTS L. LÉVY ET A. MONNIER. Brit. 445,344, April 22, 1936 (Oct. 27, 1933).

Method of producing laminated glass. ADOLF KÄMPFER. U. S. 2,038,494, April 21, 1936 (March 18, 1935).

Method of working glass and articles produced thereby. EDWARD DANNER. U. S. 2,037,853, April 21, 1936 (Feb. 9, 1933).

Method and means for feeding molten glass to glass-forming machines. UNITED GLASS BOTTLE MANUFACTURERS, LTD., AND J. TIPPING. Brit. 444,896, April 16, 1936 (Sept. 28, 1934).

Method and means for the manufacture of molded glassware. BRITISH HEAT RESISTING GLASS CO., LTD., AND P. V. W. GELL. Brit. 445,905 and 445,915, May 6, 1936 (Feb. 19, 1935).

Method and means for surfacing solid bifocal lenses. H. A. COURMETTES. U. S. 2,040,242, May 12, 1936 (May 23, 1932).

Process and apparatus for the manufacture of colored glass. SOC. ANON. HOLBREVER. Brit. 445,653, April 29, 1936 (June 5, 1934).

Process of producing laminated glass. A. W. HORNIG. U. S. 2,038,565, April 28, 1936 (March 16, 1929). (1) A process of producing laminated glass comprises the application of tin chloride solution to the glass plates to be laminated. (5) A process of producing laminated glass comprises the application of tin chloride solution to the glass plates to be laminated, in combination with the application of a distillate from mineral amyl alcohol to a celluloid sheet about to be interposed between the glass plates, and the placing of the materials to be laminated between cold, wet pads, preparatory to the application of pressure and heat.

Reflecting units for signaling, etc. CORNING GLASS WORKS. Brit. 445,069, April 16, 1936 (May 25, 1934).

Structural Clay Products

Calcium hydrosilicate as a building material. F. O. ANDEREGG. *Ind. Eng. Chem.*, **27** [9] 1019–20 (1935).—The manufacture of large steam-cured, lightweight, building units from siliceous aggregates and high-calcium pebble lime is described. Silica, ground so that approximately 98% passes a 200-mesh sieve and suspended in an excess of water, is run into a large cooker, provided with a stirrer, and high-calcium pebble lime is added. The heat of hydration of the lime is nearly enough to bring the slurry to boiling. Additional steam is introduced and the "soup" is cooked with the aid of steam under a pressure of a few pounds per square inch until a consistency is reached thick enough to hold the large amount of water added. The emulsion is then run into cast-iron forms which are vibrated to remove entrapped air. The forms are run into cylinders similar to those of the sand-lime brick industry and indurated with steam at a pressure of 150 lb./sq. in. for 7 hr. For the fabrication of brick the preliminary action may be carried to the point where reaction is nearly completed and a crumby material is formed. This may be mixed with more lime or with partly cooked slurry and pressed into brick on the brick press and cured like sand-lime brick. The name "Microporite" has been given to this lightweight calcium hydrosilicate. Although the pore space in the structural material runs from about 75 to 80%, none of these pores could be detected under a microscope even with oil-immersion lens. For structural purposes the dried product has an apparent specific gravity ranging from 0.4 to 0.8 (25 to 50 lb./cu. ft.); that used in the large units runs about 0.5 (30 lb.). For special insulation, products are readily producible as low as 0.2 (12.5 lb.). In the structural region, compressive strengths of dry materials range from 800 to 1000 lb./sq. in., flexural strengths are about 200 lb., and tensile strengths about 100 lb. Illustrated. F.G.H.

Cellulated clay units. G. A. BOLE. *Ind. Eng. Chem.*, **27** [8] 886–87 (1935).—Industrial applications of cellulated clay units are discussed, and four general methods for their manufacture are described. Illustrated. F.G.H.

Classification of brick by water absorption. W. C. VOSS. *Ind. Eng. Chem.*, **27** [9] 1021–23 (1935).—Studies of the absorptive properties of numerous clay brick permit the following generalizations: (1) For a given type of clay and manufacture, a high percentage of absorption is always found in a brick with a high coefficient of saturation. (2) A high coefficient of saturation is indicative of interconnecting capillaries or a specific gravity approaching that of the minute clay particles themselves. Such a brick, underfired and coupled with weathering, is unstable and of poor quality. (3) A low coefficient of saturation shows sealed pores and capillaries, and may easily indicate vitrification. (4) A rapid rate of absorption in the early increments of time indicates fine capillary structure, while a high percentage but moderate rate of absorption indicates an open capillary structure. (5) An absorption curve which has abrupt changes indicates partially sealed capillary planes or voids which are suddenly penetrated because of the opening up of a connecting channel by volume changes. Illustrated. F.G.H.

Development in Italian brickwork. D. P. THOMAS. *Brit. Clayworker*, **45** [528] 15–24 (1936).—A historical survey is presented. R.A.H.

Foreign methods of brickmaking. A. B. SEARLE. *Claycraft*, **8** [11] 453–56 (1935).—The methods of making brick in Europe, America, and England are compared as to costs and physical requirements. If British brick plants should adopt the methods followed in American plants equipped with the modern equipment, it would be necessary for them to produce at least 20 million brick per year for a period of ten years. Such a production schedule in England is unusual. S. states that British brick manufacturers have little to learn from foreign producers but will fare better by concentrating on the fundamental principles upon which the plant now operates. See *Ceram. Abs.*, **15** [1] 19 (1936). M.C.S.

Foremanship, a workman's point of view. JOHN PENTY. *Claycraft*, **9** [2] 75 (1935).—The various departments of a brick plant are discussed from a workman's viewpoint. M.C.S.

Manufacture of brick and tile. ANON. *Claycraft*, **9** [5] 216 (1936).—The similarity of brick and tile to slate is discussed. Nature did the pressing and firing of slate through volcanic heat and years of enormous pressure applied by the earth overlying the deposits. Similar pressure and heating are produced artificially in the manufacture of brick and tile. M.C.S.

Penetration of brickwork by damp. ANON. *Brit. Clayworker*, **45** [528] 6–7 (1936).—Conflicting results and statements obtained by the English Building Research Station and the National Bureau of Standards are discussed. R.A.H.

Proper choice of pipe materials for town sewers. HUGO BRONNECK. *Clay Prod. Jour. Australia*, **3** [5] 11–13 (1936).—This first of a series of articles by an engineer of Vienna, Austria, quotes authorities (Grün of Berlin, May of Wiesbaden, and Eisenstecken of Dortmund) who prefer stoneware, prodorite, or steel pipes to concrete. H.H.S.

Scumming and florescence. A. BRADLEY. *Claycraft*, **9** [2] 69 (1935).—The word "scum" refers to the coatings which appear on brick during their manufacture and before they leave the kiln, while "florescence" should be applied to the coatings which occur after the brick leave the kiln. There are two distinct types of scum, (1) drier-white due entirely to soluble salts present as such in the raw clay and (2) kiln-scum due to the production of soluble salts through reaction of certain substances in the clay with drier and kiln gases. The amount of scum per unit area necessary to produce objectionable results is about 0.03 g. per sq. in. Florescence is also due to soluble salts; not all of the salts, however, are present in the brick itself but may be found in the mortar used in setting the brick. The following rules are offered for eliminating soluble salts: (1) use of the barium treatment; (2) preventing drying brick from contacting the kiln gases; (3) use of a low-sulfur fuel; and (4) control of the firing procedure to give a minimum formation and maximum elimination of the sulfates. The harder the brick is fired the less will be the tendency for florescence. M.C.S.

Substitutes for lead packings in pipe joints. E. LANDEL. *Gas- & Wasserfach*, **79** [10] 145–48 (1936).—Investiga-

tions were made to replace (in Germany) the expensive lead packings in joints for sewer and gas pipes by other packing materials without having to change the shape of the ends of the (metal, clay, earthenware) pipes. Aluminum, particularly aluminum foil, is a suitable material. Its application is fully described. On the basis of the experiments, the method will be tried on a large scale in Stuttgart. M.H.

PATENTS

Apparatus for loading or piling brick, etc. E. R. Sutcliffe. U. S. 2,040,574, May 12, 1936 (July 21, 1933).

Brick veneer. E. H. Pettler. U. S. 2,040,627, May 12, 1936 (March 20, 1933).

Refractories

Action of alkalis on refractory materials: I, Action of potash vapor on refractory materials at 900° and 1000°C. F. H. Clews, A. Green, and A. T. Green. *Bull. Brit. Refrac. Research. Assn.*, No. 32 (Oct., 1933); reprinted in *Trans. Ceram. Soc.*, **34** [10] 436–55 (1935).—Of four types of refractory products, an aluminous fire clay, a normal fire clay, a siliceous fire clay, and a silica brick, exposed to the action of the vapor of molten potash at 900° and 1000°C, chemical examination indicated that the aluminous material had been affected to the greatest degree. Of a number of potash-impregnated materials held at 1000°C, the silica brick showed the greatest rate of volatilization of the alkali. For Part II see *Ceram. Abs.*, **14** [11] 278 (1935). R.H.H.P., Jr.

Alkalis and refractory materials. F. H. Clews and A. T. Green. *Bull. Brit. Refrac. Research Assn.*, No. 30 (April, 1933); reprinted in *Trans. Ceram. Soc.*, **34** [10] 425–35 (1935).—The authors consider the action in the solid, liquid, and vapor states of fluxing materials rich in alkalis on the refractories of coke ovens, glassmelting furnaces, salt-glazing kilns, and blast furnaces, and they stress the need of additional fundamental data on the volatilization of alkalis. See *Ceram. Abs.*, **14** [11] 278 (1935). R.H.H.P., Jr.

Bonding strength of cold-setting refractory cements. R. A. Heindl and W. L. Pendergast. *Bull. Amer. Ceram. Soc.*, **15** [5] 182–85 (1936).

Checker increases stove efficiency. A. Bowland. *Blast Fur. Steel Plant*, **22** [12] 695–97 (1934).—A new type patented checker for use in a blast-furnace hot blast stove is described. It has increased heating surface and great structural strength has been gained without increasing the cost per square foot of surface. Data on four stoves using these checkers show an increase in stove efficiency. Illustrated. E.J.V.

Commercial technical developments within the refractories industry during 1934. F. S. Russell. *Foundry Trade Jour.*, **52** [959] 19–20 (1935).—Progress toward the production of better refractories during the year 1934 is outlined. The installation of powerful brick presses, development of synthetic sands, use of plastic and monolithic refractories, and the improvement in special fire brick are discussed. The development of fused refractories, unfired magnesite, and the progress of insulation are also pointed out. H.E.S.

Effect of oxides of iron and chromium and a reducing atmosphere on the rate of tridymite formation in a silica-brick batch. T. R. Lynam and W. J. Rees. *Bull. Brit. Refrac. Research Assn.*, No. 28, pp. 41–48 (Aug., 1932); reprinted in *Trans. Ceram. Soc.*, **34** [12] 507–14 (1935).—A study of the effect of a reducing atmosphere on the rate of tridymite formation in a number of silica-brick batches, containing additions up to 2% of ferric oxide, chromium oxide, Prussian blue, Siemen's slag, and carbon, is described. Reducing conditions do not increase the activity of iron oxide in accelerating the formation of tridymite; chromium oxide is less effective; Siemen's slag and Prussian blue seem to favor the inversion. R.H.H.P., Jr.

Effect of the water content of silica-brick batches on the porosity of the fired brick. T. R. Lynam and W. J. Rees. *Bull. Brit. Refrac. Research Assn.*, No. 24 (Jan., 1931); reprinted in *Trans. Ceram. Soc.*, **34** [11] 500–506 (1935).—Data obtained from tests on four commercial silica-brick batches containing from 5 to 15% water indicate that a low moisture content results in a lower porosity. R.H.H.P., Jr.

Experiments on the grading, porosity, and permeability to air of silica brick. F. H. Clews and A. T. Green. *Bull. Brit. Refrac. Research. Assn.*, No. 31 (June, 1931); reprinted in *Trans. Ceram. Soc.*, **34** [11] 457–66 (1935).—Permeabilities to air as low as 0.04 together with porosities as low as 20% have been obtained in silica brick prepared from batches of ground ganister graded for maximum packing density and pressed at pressures up to 6¾ tons per sq. in. See *Ceram. Abs.*, **14** [11] 279 (1935). R.H.H.P., Jr.

Fireclay refractories for glassworks use: X. Anon. *Glass*, **12** [10] 416 (1935).—Glass-tank furnace blocks are classified and described. **XI.** *Ibid.*, [11] 452.—The selection of refractory materials for tuck-stones and port-hearths is dependent upon the working temperatures of the furnace; they include silica, sillimanite, and corundum. Refractories which stand up best in the ports contain approximately 45% corundum, 45% mullite, and 10% glass, and the grog is fine and even, ranging in size from ⅛ to ¼ in. Regenerator refractories should contain from 40 to 60% mullite. Greater efficiency in glass tank operation is being effected through proper insulation. **XII.** *Ibid.*, [12] 500 (1935).—The chief tests used to determine the adaptability of materials for glasshouse use may be classified generally as follows: (*a*) tests on cold samples, which include chemical analysis and porosity and permeability; (*b*) determination of physical properties at high temperatures, including squatting tests, refractoriness under load, thermal expansion, and after-contraction; (*c*) high-temperature laboratory tests of corrosive attack; and (*d*) simulative service tests. For Parts VII–IX see *Ceram. Abs.*, **15** [4] 124–25 (1936). M.C.S.

Gas retorts. A. A. Fazel and N. N. Fantalov. *Ogneuporui*, **3** [4] 265–68 (1935).—The process of production and the properties of refractories used for gas retorts are described. Characteristics of retorts made from different compositions of the mass are given in a table. P.B. & E.S.

Hand- and machine-molded silica brick. R. KLESPER. *Sprechsaal*, **68** [38] 581–83; [39] 597–601 (1935).—A detailed discussion is given of methods used for producing hand- and machine-molded silica brick for steel furnaces and coke ovens. Tables show their respective properties. Illustrated. M.V.C.

History of crucibles. OTTO VOGEL. *Glashütte*, **65** [46] 722–23 (1935).—The production of crucibles in the 17th and 18th Centuries and the attempt of V. to obtain satisfactory crucibles from a mixture of talc and refractory clay are described. Such crucibles when heated are not attacked by powdered lead glass. M.V.C.

Manufacture and testing of silica brick. D. C. NAG. *Quart. Jour. Geol., Mining & Met. Soc. India*, **3** [4] iii (1932).—Good silica brick should have more than 60% tridymite, less than 25% cristobalite and quartz, 4% basic oxides, 6 to 8% fused silica; they should possess absolute specific gravity between 2.3 and 2.4 and a porosity between 25 and 30%, and should be fired at 1400° to 1500°C for about 3 weeks. N. describes his method of examination; chemical composition, specific gravity, and the method of examination appear to give a fairly reliable estimation of the quality of silica brick. A.P.S.

Methods for testing spalling of refractory materials. E. KELER AND A. ZAKHAROV. *Trudui Vsesoyuz. Nauchno-Issled. Inst. Keram.*, No. 46, pp. 52–69 (1935); see *Ceram. Abs.*, **14** [9] 218 (1935). M.V.C.

Mineral wool and vermiculite as insulation. J. A. SCHAEFFER. *Ind. Eng. Chem.*, **27** [11] 1298–1303 (1935).—The characteristics of various insulation materials for the manufacture of insulating brick are described, and their physical properties are compared. Illustrated. F.G.H.

Natural acid refractory materials. A. A. TUILIK. *Ogneuporui*, **3** [4] 280–82 (1935).—The use of sandstones and other minerals as refractory materials is discussed in detail. M.V.C.

Nozzle and stopper rod assemblies. H. V. BEASLEY. *Blast Fur. Steel Plant*, **21** [10] 527–29; [11] 581–86 (1933).—Several precautions for obtaining the best pouring practice with graphite stopper rod assemblies are given. Illustrated. E.J.V.

Producer and consumer of refractory materials. HANS KREMSKI. *Tonind.-Ztg.*, **59** [95] 1173–75 (1935).—K. discusses (1) properties of refractories, (2) composition and structure, and (3) furnaces. M.V.C.

Production and uses of insulating fire brick. ANON. *Metal Ind.* [London], **47** [25] 608–10 (1935).—The advantages, limitations, and methods of use in furnace design are discussed. H.E.S.

Refractories in the foundry. H. C. BIGGS. *Foundry Trade Jour.*, **52** [979] 351–54 (1935).—The more important properties of refractory materials such as (*a*) refractoriness, (*b*) resistance to deformation under load, (*c*) volume changes at working temperatures, (*d*) spalling resistance, and (*e*) resistance to corrosion and erosion by slags are reviewed. The conditions in the cupola are considered, and suggestions for making the best use of the materials available are offered. H.E.S.

Refractoriness and its determination. F. H. CLEWS AND A. T. GREEN. *Bull. Brit. Refrac. Research Assn.*, No. 34 (June, 1934); reprinted in *Trans. Ceram. Soc.*, **34** [11] 467–99 (1935).—(*a*) For the refractoriness test, the factors responsible for the softening range and the melting behavior of clays and clay products are considered in detail. The standard pyrometric cone tests of Great Britain, America, and Germany are critically reviewed and it is suggested that, since they are essentially high-temperature deformation tests under light load, the load test be substituted as a measure of refractoriness. (*b*) For the refractoriness-under-load test, see *Ceram. Abs.*, **14** [11] 281 (1935). R.H.H.F., JR.

Refractory concrete. ANON. *Glass*, **12** [10] 427 (1935).—*Ciment fondu*, when used with alumina firebrick grog, produces a concrete that withstands temperatures up to 1300°C or higher. In addition it has a low thermal expansion, high strength (cold or hot), and is resistant to dilute acid attack. M.C.S.

Selection of checker brick from the thermal viewpoint. J. LAMORT. *Glashütte*, **66** [2] 32–35; [3] 51–55; [6] 94–96; [7] 109–10; [8] 132–34 (1936); translated in *Glass*, **13** [3] 114–18 (1936). On the basis of known facts as to thermal conductivity figures of refractories of known specific heat, specific gravity, and porosity figures, the effect of increased porosity on the exchange of heat of checker brick and the lowering of the preheating temperature during stoppage was calculated. The amount of gases penetrating into the pores of checker brick is so small that it has no effect on heat exchange. Experiments were made with grog brick, silica, brick of the sillimanite-mullite series, corundum, chromium, zirconium, magnesite, and silicon-carbide brick, and cast-iron beams and plates. Contrary to prevalent ideas, the porosity of brick has an unfavorable effect, and dense brick are thermally the best as to heat exchange and drop in temperature during stoppage, because of their better heat conductivity and ability to retain their heat. The idea that brick of high thermal conductivity give off their stored heat too rapidly is without grounds. The superiority of silica brick over grog brick at 800°C was not determined. Grog brick fired at higher temperatures have a higher rate of thermal conductivity than those fired at lower temperatures. Checker brick for heat recuperators should be fired well; lean grog brick require lower temperatures than fat brick. The effect of the alumina content in grog brick was not determined. The effect of increased alumina content on heat conductivity and storing appears first in the bauxite-sillimanite-mullite series and becomes a decisive advantage in corundum brick with 80% alumina. Heavy chrome ore and zircon brick belong to the same class; only silicon carbide and magnesite brick can develop a greater heat exchange because of their higher thermal conductivity. Cast iron is the best heat-storing material, having the highest thermal conductivity and specific heat. When the brick is less thick, the effect of thermal conductivity decreases, while that of accumulating heat increases. It can be concluded that when the brick is less thick or the time of stoppage is longer, a high ability to store heat is of special advantage, while with a greater thickness and shorter stopping time, thermal conductivity is especially important. M.V.C.+M.C.S.

Utilization of alunite through fusion with alkali sulfides. E. O. HUFFMAN AND F. K. CAMERON. *Ind. Eng. Chem.*, **28** [4] 420–22 (1936).—Alunite is completely decomposed by fusion with sodium sulfide or with mixtures of coal and

either sodium sulfate or potassium sulfate. When sodium sulfate is used, a satisfactory recovery of alumina is effected readily, but recovery of potassium as a pure salt is difficult and may not be practicable. When potassium sulfate is used, fusions are more easily effected, recovery of alumina approaches perfection, and potassium may be completely recovered as the sulfate and the carbonate. Recovery of a pure potassium salt can be accomplished readily by standard procedures. See *Ceram. Abs.*, **14** [10] 251 (1935). F.G.H.

Zanite, new heat-insulating material. E. Partiot and P. Walter. *Rev. Gén. du Froid*, **15** [2] 42 (1935); abstracted in *Sprechsaal*, **69** [5] 64 (1936).—Zanite is light weight and its thermal conductivity is about that of cork; it is foliated and sinters at 1400°. The mineral contains aluminum-magnesium silicate, some iron, and other constituents. It is treated and fired. It is added to gypsum, cement, magnesia, and water-glass and is a good soundproof and high-temperature insulating material when mixed with refractory materials (1300 to 1400°C). It is unaffected by acids and vapors. M.V.C.

BOOKS AND BULLETINS

Accidents in the refractories industry, can they be prevented? F. H. Atwood. *Amer. Refrac. Inst. Tech. Bull.*, No. 62, 8 pp. (Feb., 1936).—In 1934 there were 101,000 accidental deaths in this country, an average of 271 a day. At one large plant where exact records are kept, however, the average employee was found to have sustained six accidents outside the plant to every one within; this ratio is increasing every year. Most of the improvement in industry can be traced to adoption of Workmen's Compensation Laws by practically all the states. For the year 1934, the clay products industry stands 25th in a list of 30 industries in accident-frequency rate. The cause and prevention of industrial accidents are analyzed and presented. Industry has made a notable contribution to the cause of safety, but the fight against industrial diseases has only begun and sooner or later Workmen's Compensation Laws will be extended to include occupational diseases. H.E.S.

Comments on the refractories industry. J. M. McKinley. *Amer. Refrac. Inst. Tech. Bull.*, No. 59, 10 pp. (June, 1935).—The entire historical background of the refractories industry is reviewed to show the present underlying trends in the industry. The present technical background upon which current specifications rest is briefly reviewed. Technical tests are analyzed critically. The value of technical literature and coöperating societies is pointed out. The importance of having some background from a service survey in every proposed project is stressed. M. characterizes the refractories engineer of yesterday and of today; the future engineer "will have to be the best example of an all-around engineer that the arts have yet turned out." H.E.S.

Insulation and control of open-hearth furnaces. William C. Buell, Jr. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 641, 15 pp. (1935).—Insulation below the charging floors of open-hearth furnaces is now generally accepted practice. The benefits of application to the rest of the structure are still being argued. To be effective, insulation should be applied only where the furnace system is correctly designed and the operation practice is appropriately modified. The bearing of choice of insulating materials and of heat-flow relationships is discussed. "Control" is defined as the mechanization of management functions. The factors requiring control and methods of accomplishing it are listed. Improvements in either insulation or control should not be attempted except as part of planned betterment programs. See *Ceram. Abs.*, **14** [11] 280 (1935). A.P.

Manufacture of Glass-House Refractories. M. Ya. Krivitskaya. State Pub. House Light Ind., Moscow, 1935. 68 pp. Price 70k. This is a popular brochure on the subject. S. I. Perkal

Properties of insulating refractories: I, Behavior under load at high temperatures. S. M. Phelps. *Amer. Refrac. Inst. Tech. Bull.*, No. 61, 6 pp. (Dec., 1935).—Two types of load tests for insulating fire brick are described. In one test, four brick are arranged in the furnace so that the proportioned load can be applied to the 9- x $4^1/_2$-in. faces of the brick. Insulating brick are placed at the sides of the group of test brick so that the furnace heat is applied only to the 9- x $2^1/_2$-in faces of the four brick. The furnace is operated at 2500°F for 24 hr. and the load is applied during this time. In another test, two columns of brick laid flat and seven high are subjected to a proportional load. The test brick are heated on one face only and are backed up with a $4^1/_2$-in. wall of insulating brick from the same lot. The surface of the test panel is heated to 2500°F and maintained at that temperature for 24 hr. This type of test shows that the better grades of insulating refractories possess satisfactory mechanical strength at the maximum temperature which they are intended to stand in service. H.E.S.

Properties of refractory materials not including fire clays. S. M. Phelps. *Amer. Refrac. Inst. Tech. Bull.*, No. 57, 5 pp. (April, 1935); also in *Refrac. Jour.*, **11** [8] 394 (1935).—The properties of various refractory materials, not including the fireclay group, are presented. A table containing more recent data pertaining to melting point, true specific gravity, hardness, specific heat, thermal expansion, and thermal conductivity is included. Fireclay materials, because of their wide range in properties, are to be included in a separate report. H.E.S.

Red hearts in firebrick and fireclay shapes. C. M. Dodd and S. R. B. Cooke. *Amer. Refrac. Inst. Tech. Bull.*, No. 56, 8 pp. (Feb., 1935); see *Ceram. Abs.*, **14** [8] 190 (1935). H.E.S.

Refractories in vertical lime kilns. C. E. Bales. *Amer. Refrac. Inst. Tech. Bull.*, No. 55, 6 pp. (Jan., 1935).—In the shaft of the kiln, the brick encounter considerable abrasive action, rough handling, and chilling when the "stick" system is used, slag action, and an average temperature of 2300 to 2400°F. In the fire-box arches, the brick are subjected to a temperature of 2400°F, slag action, and rapid changes in temperature. High heat-duty, machine-made, hard-fired fire brick are used although in a few cases silica brick and high alumina brick have been used. Some cases of refractory failure are due to operating conditions and faulty design of the kilns. H.E.S.

Specification and test methods for cold-set cements. S. M. Phelps. *Amer. Refrac. Inst. Tech. Bull.*, No. 60, 8 pp. (Sept., 1935).—There are many high-temperature

bonding mortars of the cold-set variety. Tentative specifications adopted by the American Refractories Institute cover the suitable selection of these mortars for use with clay refractories in the construction of boiler furnaces and incinerators. The test requirements are as follows: for (1) particle size, 95% must pass a 28-mesh Tyler sieve; (2) water-retention test, the water-retention period must be not less than 2 min.; (3) cold-set strength, the average strength of dry unfired joints must be not less than 100 lb./sq. in.; (4) refractoriness test, the mortar must not flow out of the joint in the 1500°C refractoriness test.

H.E.S.

Standard Hand Book of Refractories. Standard Fuel Engineering Co., 667 S. Post Ave., Detroit, Mich. 48 pp. Free. This manual for engineers, plant superintendents, and others interested in the control of heat contains information on refractory cements, refractories, and heat-treating and other furnaces; there is also a copious assembly of useful tabular material of interest to those whose use of refractory materials requires specific formulas.

Thermal spalling of fireclay brick in relation to Young's modulus of elasticity, thermal expansion, and strength. R. A. Heindl. *Amer. Refrac. Inst. Tech. Bull.*, No. 58, 7 pp. (May, 1935).—In studying the properties of fire brick, a distinct lack of uniformity was noted not only between units but also within the individual unit of any manufacturer's product. The variation of modulus of elasticity may be over 180%. Thermal expansion was shown to decrease considerably by reheating to 1400°F for 5 hr. The extensibility or ability to stretch without rupture of fireclay brick is usually decreased with increase of firing temperature. The effect of these variations on thermal spalling is pointed out. The effect of the porosity and size of grog on these properties is also discussed.

H.E.S.

PATENTS

Furnace linings. A. F. Meyerhofer and E. A. Meyerhofer (trading as Meyerhofer & Co.). Brit. 444,878, April 16, 1936 (Dec. 2, 1933).

Methods of making refractory materials. Alexander Rava. U. S. 2,040,215, May 12, 1936 (May 15, 1933). The method of fusing and melting a granular and/or pulverized mass of refractory material includes producing two relatively low-voltage d.-c. arcs between two pairs of electrodes, directing the arcs by respective magnetic fields upon relatively adjacent portions of the mass surface, then establishing two relatively high-voltage a.-c. arcs, each in one of the d.-c. arcs and in an electric circuit comprising the a.-c. arcs and the portion of the mass therebetween to effect melting portions of the mass into a pool by the heat of the arcs and of the current flowing through the mass between the a.-c. arcs.

Process of making bonded silicon carbide refractories. R. C. Benner and G. J. Easter (Carborundum Co.). U. S. 2,040,236, May 12, 1936 (June 30, 1932). The step in the method of making silicon carbide refractories containing at least 80% of silicon carbide, with the remainder composed substantially of magnesium aluminate, comprises heating up the refractory mixture rapidly in a non-oxidizing atmosphere to a temperature at which the bond softens, the firing being continued long enough to soften the bond but not long enough to cause recrystallization of the silicon carbide.

Terra Cotta

Attempts to produce yellow brick with additions of Wintersurjk marl. J. R. Metzler. *Klei*, No. 4, pp. 30–32; No. 6, pp. 52–54 (1935); abstracted in *Tonind.-Ztg.*, **59** [91] 1136 (1935).—A 32%, 35%, and 40% addition of dolomitic marl produced a yellow-colored brick after a 4-hr. firing. Magnesia also promotes yellow coloring.

M.V.C.

Ceramic ware for the chemical industries. R. D. *Verre & Silicates Ind.*, **7** [9] 106–108 (1936).—A study of the form, thickness, and regularity of sides of ceramic ware is necessary to obtain ware resisting thermal shock. Directions for heating the pieces should always be specified.

M.V.C.

Comparison of tiling materials. Anon. *Keram. Tile Jour.*, **8** [3] 4–9, 12–17 (1936).—A photographic description of physical defects in various types of tiling materials, including glass, vitreous enamel tile, lacquered metal, lacquered sheets on composition, asphalt, rubber, and linoleum, is given. M.C.S.

Glazed pottery manufacture. W. B. Rowley. *Jour. Soc. Chem. Ind. Victoria*, **35**, 1034–47 (Sept., 1935).—Processes at the Hoffman Brick and Potteries, Ltd., plant, Melbourne, are described. Practical applications of a process, such as alkaline slip-casting, are far in advance of our understanding of the theoretical principles underlying them. Pottery is one of the earliest of Australian manufactures. H.H.S.

Green spots on glazed-fireclay products. Maurice Barrett. *Brit. Clayworker*, **44** [527] 371 (1936).—This defect takes the form of green spreading spots or dark-colored metallic spots surrounded by a green halo. These spots are due to copper introduced as an impurity. Two methods for remedying the defects are discussed in detail, (1) mechanical removal of impurity, and (2) chemical treatment. Little benefit is gained by the chemical treatment of the clay. R.A.H.

Lockon system of tile-setting giving new business. Anon. *Keram. Tile Jour.*, **8** [2] 4 (1936). M.C.S.

Manufacture of ceramic stoneware. A. C. *Rev. mat. constr. trav. pub.*, No. 318, p. 48B (1936).—The manufacture in France of stoneware for the chemical industry is briefly summarized from the work of G. Vié (see "Manufacture of earthenware," *Ceram. Abs.*, **15** [3] 96 (1936).)

M.V.C.

Manufacturing fused Dutch tile. Ernst Kempe. *Sprechsaal*, **69** [1] 3–4 (1936).—The successive stages in the manufacture of Dutch tile and glazes for stoves, at the Velten plant at Mark (Prussia), are described. M.V.C.

Production defects of mosaic tesserae. W. Steiner. *Sprechsaal*, **68** [47] 719–21 (1935).—Directions for grinding, storing, drying, and pressing are given. Tesserae are fired to cones 7 or 11. Defects which may appear during the successive stages of production are discussed.

M.V.C.

PATENTS

Ceramic baths. Établissements Jacob-Delafon Compagnie Céramique de Pouilly-sur-Saone et Belvoye. Brit. 445,756, April 29, 1936 (Oct. 5, 1934).

Glazing of brick, tile, etc. F. G. Gatensbury and J. H. Boycott. Brit. 445,170, April 16, 1936 (Oct. 10, 1935).

Production of colored surfaces on unglazed brick and earthenware. W. H. A. Thiemann (I. G. Farbenindustrie A.-G.). Brit. 446,005, May 6, 1936 (Jan. 10, 1936).

Whiteware

Agreement of mixes and ceramic glazes. Jacques H. Benrubi. *Verre & Silicates Ind.*, **7** [6] 61–65; [7] 73–77; [8] 90–93 (1936).—B. concludes that (1) a ceramic glaze almost always has tensions above its transformation point. These tensions promote crazing. (2) They are a function of the rate of cooling for a given glaze and base and may be diminished by stabilization during cooling (the furnace is stabilized with the use of a regulator) at temperatures between the transformation temperature and the temperature of the beginning of tensions. (3) For a given stabilization time there is a temperature of stabilization at which the tensions existing at ordinary temperatures are at a minimum. (4) Experiments show that ceramic glazes can be tempered. Tempering, which brings the surface of the glaze under compression, lessens the tendency to craze and can give the glaze great thermal and mechanical resistance. M.V.C.

Better electrical insulators with the potter's aid. Joseph C. Rah. *Elec. Mfg.*, **15** [1] 28–30 (1935).—Insulator characteristics depend on the proportions of clay, feldspar, and flint used. By means of a ternary composition diagram, the areas for optimum combinations of dielectric strength, mechanical strength, and resistance to thermal shock are indicated. R. describes in detail the compounding, production methods, and technology of electrical porcelain manufacture. Methods of preparing the slip are similar, but final treatment may be by the casting, plastic wet, or dry processes. In glazing it is essential that the thermal characteristics of the glaze be identical with the porcelain itself to avoid "crazing." F.P.P.

Breakdown of dielectrics. C. J. O. Garrard. *Electrician*, **116** [12] 373–76 (1936).—A discussion of the nature and mechanics of the electrical breakdown of a gas, causing the surface flashover of solid insulators, is presented. H.K.R.

Ceramic firing processes: III, Effect of firing conditions on structural changes. Otto Krause and Eberhard Keetman. *Sprechsaal*, **69** [4] 45–47; [5] 57–59; [6] 73–75; [7] 85–87 (1936).—Three hard porcelain bodies fired under different conditions were studied as to changes in their quartz and feldspar content to determine the effect of firing temperature, firing time, and furnace atmosphere; (*a*) changes in specific gravity, (*b*) changes in quantity, number of grains, and grain size of quartz, and (*c*) growth of mullite crystals were determined. (1) Feldspar liquefies at 1100°C although it is not a pure melting process but is caused by the formation of a silica-feldspar eutectic. The true melting of feldspar takes place at higher temperatures. The feldspar melt formed during firing dissolves the quartz present. With isothermic heating, the dissolving of quartz dependent on time may be approximately represented by the function, $C_o - C = K \cdot \log t$, where C_o = original quartz content, C = quartz content after t, and K = a constant. (2) Experiments show that the amount dissolved depends considerably on the amount of quartz present and not on that of feldspar. The ability of liquefied feldspar to absorb quartz or silica is high. The smaller quartz particles disappear first during dissolving, and an increase of the mean grain diameter is observed with a progressive heating time. (3) The glassy-amorphous phase, calculated from the dissolving of the quartz quantities by the feldspar melt, increases uniformly with the logarithm of the firing time. (4) A reducing atmosphere promotes the dissolving of quartz only below 1300°, due to an increased capacity of the melt containing iron to dissolve quartz. (5) The effect of moistening the furnace atmosphere on the dissolving of quartz and the exact amount of mullite originated could not be determined. From X-ray experiments and those of Rieke and Schade (*Ceram. Abs.*, **11** [12] 622 (1932)), it is concluded that the quantity of mullite originated is determined chiefly by the amount of clay substance introduced into the mix. (6) The question of the growth of mullite crystals is determined by the fact that this growth occurs only at higher temperature and can be represented with isothermic heating by the function, $l = b \cdot \log t$, in which l = mean length of mullite crystals after a firing time, t, with isothermic heating; b = velocity constant. (7) Because of a low solubility of mullite in feldspar, only a small proportion of the fused phase is absorbed. The undissolved mullite crystals grow at over 1200° (probably at the expense of the smaller crystals) at a rate which is again determined by the coefficient of diffusion dependent on the viscosity of the feldspar melt. Of special importance is the fact that a lengthening of the firing time at temperatures below the highest temperature produces neither a mullite growth nor a dissolving of quartz; instead a standstill of all structural changes occurs. For Part II see *ibid.*, **14** [10] 255 (1935). M.V.C.

Data on the influence of firing time on the properties of some whiteware bodies. Arthur S. Watts. *Jour. Amer. Ceram. Soc.*, **19** [6] 175–76 (1936).

Determination of the width and number of pores and the permeability of filter ware. Hermann Ruoss. *Kolloid-Z.*, **74** [2] 221–24 (1936).—The method of determination based on the viscosity constant of a liquid is described. The method consists in measuring the time required for a column of water to be reduced in height a specific distance by flowing through a filter plate of the material. The required size may be calculated from this time period and the pore space. F.P.P.

Fluxing effect of feldspar in whiteware bodies. E. Schramm and F. P. Hall. *Jour. Amer. Ceram. Soc.*, **19** [6] 159–68 (1936).

Gray-black spots in decorated porcelain. K. Litzow and Th. Heidenreich. *Sprechsaal*, **69** [3] 29–30 (1936).—The black spots and points appearing in decorated enamel and in refired ware at 450° are caused in the glost firing.

The blisters contain CO_2 which splits into CO and C, or hydrocarbon which may also precipitate carbon. To avoid these defects, the porcelain glaze must be thoroughly melted. Gases containing carbon which may be inclosed in the glaze should be burned out. M.V.C.

Life of Josiah Spode. ANON. *China, Glass & Lamps*, **53** [10] 30–34 (1934).—Spode's principal contributions to the ceramic industry are discussed comprehensively. Illustrated. G.M.P.

Mason, the potter. ANON. *China, Glass & Lamps*, **54** [3] 26–27 (1934).—Mason perfected and patented ironstone china with its infusion of iron slag. Illustrated. G.M.P.

Porcelain. ANON. *China, Glass & Lamps*, **53** [9] 15 (1934).—The term "porcelain" is much misused. Fantastic stories were invented regarding the makeup of porcelain. G.M.P.

Practical manufacture of high-tension porcelain insulators. ANON. *Sprechsaal*, **68** [43] 661–62 (1935).—A brief general discussion is given. M.V.C.

Studies of the structure of ceramic diaphragms by electrical measurements. J. VELIŠEK AND A. VAŠIČEK. *Kolloid-Z.*, **71** [1] 36–48 (1935).—Three types of porcelain diaphragms were studied with special reference to the relation between electrical resistance or conductivity and the geometric dimensions of the diaphragm. With constant thickness, the conductivity was proportional to the surface area, while with constant surface area the resistance was proportional to the thickness with only one type of porcelain. The anomalies observed with the other two are attributed to their abnormally fine structure. F.P.P.

BOOKS AND BULLETIN

Better buymanship: No. 18, dinnerware. MARTHA B. KING. Household Finance Corp., Chicago, Ill., 1936. 26 pp. Price two for 5¢; in lots of fifty 1¢ each. The differences between and the particular merits of the various types of dinnerware including earthenware, semivitreous chinaware, china, and porcelain are discussed. The types of ware and of decoration, classes or grades of ware, defects and imperfections to be found in tableware, and the factors which determine the price of dinnerware are dealt with. M. C. SHAW

Chemical porcelain ware. ANON. Coors Porcelain Co., Golden, Colo., 1935. 56 pp. Free. A complete account is given of the process of the Coors Porcelain Co. in manufacturing chemical porcelain. Illustrated. M. C. SHAW

PATENTS

Ceramic electric insulating material. W. BLOCH. Brit. 445,269, April 22, 1936 (Sept. 4, 1934).

Electrical insulator and method of making. CHAMPION SPARK PLUG CO. Brit. 446,106, May 6, 1936 (Nov. 8, 1933).

Method and means for preparing refractories and refractory masses so produced. EMIL KLINGLER (Robert Bosch A.-G.). U. S. 2,040,051, May 5, 1936 (Nov. 1, 1933). A spark plug has as insulator a ceramic mass containing refractory oxide and calcined zeolite.

Process of assembling insulators. J. J. TAYLOR (Ohio Brass Co.). U. S. 2,039,500, May 5, 1936 (Oct. 26, 1934).

Spouts, particularly for teapots, etc. W. S. HOPPER. Brit. 445,470, April 29, 1936 (Oct. 6, 1934).

Strain yoke for electrical conductors. J. J. TAYLOR (Ohio Brass Co.). U. S. 2,039,499, May 5, 1936 (Aug. 1, 1934).

Trunnion clamp for conductors. J. J. TAYLOR (Ohio Brass Co.). U. S. 2,039,501, May 5, 1936 (May 29, 1935).

Equipment and Apparatus

Aspiration psychrometer (for determining air humidity). J. P. FRIEZ & SONS. *Instruments*, **9** [3] 60 (1935).—The new electric thermo-shield psychrometer eliminates error from heat radiation of surrounding objects (including the operator) by drawing the air sample through the top of the apparatus. The initial warmth effect of the wet-bulb reservoir is eliminated by individual applications of water to the wet-bulb for each reading. The entire apparatus is cased in a highly polished chromium plated thermo-shield, approximately 7 in. square by 13 in. high, equipped with a glass window for reading thermometers and an integral rack for psychrometric tables. Thermometers are 10 in. long, carefully matched, and graduated from −5 to +130°F in 0.5°F increments. The fan is operated by a 110-volt a.-c.motor. R.W.R.

Bakelite press for mounting mineral grains and ores. F. L. STILLWELL. *Proc. Australasian Inst. Mining Met.*, No. 90, pp. 237–46 (1933). A.H.E.

Bin shapes and feeders, their importance to the process. H. HARDINGE. *Ind. Eng. Chem.*, **27** [11] 1338–41 (1935).—Bin construction and methods of feeding are discussed as to the effect of bin shapes upon characteristics of the feed. Illustrated. F.G.H.

Comparator for mortar specimens. GAERTNER SCIENTIFIC CORP. *Instruments*, **9** [4] 98 (1936).—This apparatus utilizes two microscopes mounted on adjustable supports on a rugged base and is designed for the accurate linear measurement of cement and concrete specimens in research and routine tests. One microscope is firmly clamped to its rod support and the other is mounted in a precision micrometer slide of 25 mm. range, reading direct to 0.01 mm. It can be supplied with English or metric graduations. R.W.R.

Comparison of statically and dynamically determined Young's modulus of rocks. JOHN M. IDE. *Proc. Nat. Acad. Sci.*, **22** [2] 81–92 (1936).—I. determined Young's modulus dynamically on a number of rocks using cylindrical specimens. These were set into vibration by electrostatic traction, the fundamental longitudinal resonance frequency was determined, and Young's modulus was found from this (see *Rev. Sci. Instruments*, **6** [10] 296–98 (1935) for detailed description of method). Three tables compare the values obtained with those obtained from static determinations. 15 references. J.L.G.

Cumming's crucible furnace. GRAMOPHONE CO. *Foundry Trade Jour.*, **52** [984] 437 (1935).—Operating data of the Cumming's rapid-melting crucible furnace are presented. The furnace is used for melting aluminum, gun-

metal, cast iron, and Monel metal. The saving in coke recorded is of the order of 50% over the type of pit-fired furnace previously used. Illustrated. H.E.S.

De-airing of clay: its claims considered. EDITORIAL. *Clay Prod. Jour. Australia*, **3** [5] 1–2 (1936).—The cumulative testimony of all countries that have tried this U. S. invention is that it produces better goods with less waste. For an Australian-made machine see *Ceram. Abs.*, **15** [2] 68 (1936). H.H.S.

Drum driers. C. R. HARTE, JR. *Ind. Eng. Chem.*, **28** [1] 7–10 (1936).—The application of the drum drier to the drying of liquids and slurries, such as clay suspensions, is discussed. Drum driers in general, and the various types of drum driers (atmospheric single-drum, vacuum single-drum, and the double-drum driers) in particular, are selected for any given drying requirement on the basis of their individual operating characteristics and costs. These factors are examined and discussed in detail. Illustrated. F.G.H.

Electric driving and timing apparatus for microcinematography. A. GOETZ AND A. ROMER. *Rev. Sci. Instruments*, **7** [1] 6–11 (1936).—Two applications of this apparatus in the field of microcinematography are described: (1) determination of the falling speed of suspended colloid particles in an ultramicroscope, and (2) recording of the growth of etch figures on crystal planes produced by electrolysis. H.E.S.

Electric tachometers. LEEDS & NORTHRUP CO. *Instruments*, **9** [4] 95 (1936).—Two d.-c. tachometric magnetos are announced, which, in connection with the maker's industrial d.-c. recording potentiometers, provide a variety of combinations for plant and laboratory measuring applications. R.W.R.

Equipment for measuring viscosity accurately in fundamental units. M. R. CANNON AND M. R. FENSKE. *Oil & Gas Jour.*, **34** [47] 45–46, 48–49 (1936).—The principles and operation of a simple all-glass routine viscometer, which has been found to measure accurately the viscosity of petroleum products in fundamental units, are described, as well as the construction of the constant-temperature bath. This bath may be stirred by a motor-driven stirrer or by air introduced through an Alundum porous tube. A simple thermoregulator using a vacuum tube to operate the relay system is also discussed. R.W.R.

Flash drying for materials of high moisture content. RICHARD F. O'MARA. *Chem. Met. Eng.*, **43** [4] 186 (1936).—Flash driers are designed for rapidly drying high-moisture materials. The material is first partially dewatered in filter presses or evaporators and then is fed into a high temperature air stream which carries it into an agitator where it is violently agitated in contact with the hot air. Leaving the agitator, the material is carried in suspension by air to an air separator where the solids are separated from the vapor-laden air. M.C.S.

High speed oil-diffusion pump. H. W. EDWARDS. *Rev. Sci. Instruments*, **6** [5] 145–47 (1935).—A 3-in. pump operating on a western mineral oil is illustrated and explained. The pumping speed is in excess of 50 liters/sec. at a pressure of 1.0×10^{-4} mm. H.E.S.

Illuminated field magnifier. E. W. PIKE AND CO. *Instruments*, **9** [3] 61 (1936).—This apparatus uses a double-lens system giving 5× magnification in a 2-in. field, a Bakelite spacer ring holding the lens in proper focus. The field is illuminated by a shielded lamp, operated by flashlight batteries or from the lighting system. R.W.R.

Improvements in grinders. A. ROUY. *Recherches & Inventions*, No. 251, pp. 413–14 (1935); abstracted in *Chim. & Ind.*, **35** [3] 553 (1936).—In the invention described, a cutting force is substituted for a crushing force. Details are given. M.V.C.

Make testing serve, not retard production. G. E. HANN. *Instruments*, **9** [3] 75–76 (1936).—When possible, it frequently facilitates production to simplify control tests and have them made at the point of production, thus also relieving the laboratory from routine work. The test operations should be reduced to simple numbered steps and the most promising man on each process instructed carefully in the different steps and the reasons for them. Check samples may be used as a precaution. Log sheets of the tests should be kept. R.W.R.

Method for casting molybdenum buttons in brass for water-cooled targets in X-ray tubes. F. H. TRIMBLE. *Rev. Sci. Instruments*, **6** [8] 216 (1935). A water-cooled target has been successfully used in a demountable X-ray tube. H.E.S.

Molding sand testing apparatus. H. W. DIETERT. *Sands, Clays & Minerals*, **2** [4] 161–66 (1936).—Methods and apparatus for testing strength, moisture, fineness, permeability, flowing property, sintering point, and deformation are described. M.H.

Nephelometry as an aid in the investigation of mineral substances. JULIUS GRANT. *Sands, Clays & Minerals*, **2** [4] 91–96 (1936).—Principles of measuring by haze or turbidity produced in a solution when two substances react with one another are explained, and different apparatus is described. The sensitiveness of many nephelometric methods is increased considerably when using a mercury vapor lamp as a source of illumination. The application to problems of determination and control of smoke, fumes, and dust is briefly described. M.H.

Photography with ultra-violet and infra-red light. KONRAD ROSS. *Zeiss Nachr.*, **4**, 19–25 (1933).—The manufacture of ultra-violet sensitive and infra-red sensitive photographic plates is described. The possibilities for industrial research are outlined. Illustrated. L.E.T.

Planimeters and integrimeters. L. A. OTT. *Messtechnik*, **12** [3] 41–45 (1936).—A few new constructions deviating from the usual type and principle of planimeters, but simpler in theory and manipulation, are described. Most of the new instruments permit the evaluation of any function and irregular diagram and curve. M.H.

Promotion of the drying of clay by the coagulating effect of acid: I. H. H. MACEY. *Trans. Ceram. Soc.*, **34** [9] 396–416 (1935); for abstract see *Ceram. Abs.*, **15** [1] 31 (1936). R.H.H.P., JR.

Pug-mill indicator. B. G. MAYS. *Claycraft*, **8** [12] 493 (1935).—The indicator consists of a loose-running wheel connected to a pinion carrying an indicator arm; this arm is mounted with respect to an indicating calibrated quadrant. The apparatus is placed directly over the column of clay as it is extruded from the die, and the depth to which the loose-running wheel penetrates the clay column is indi-

cated on the quadrant which is calibrated in the three classifications, (1) soft, (2) normal, and (3) hard. M.C.S.

Removal of moisture from compressed air. E. I. Lloyd. *Glass*, **13** [2] 72 (1936).—Three general methods of removing moisture from a compressed-air system are (1) receivers or after-coolers wherein the air is cooled to around 80°F, which lowers the moisture-carrying character of the air, (2) water separators wherein the moisture is removed through centrifugal action or a similar force, and (3) drain cocks. M.C.S.

Rotary drilling fluids. P. Evans. *Sands, Clays & Minerals*, **2** [4] 9–22 (1936).—The various drilling methods in the oil fields are reviewed and the recent more widely used rotary-drilling method is described. The circulating fluid (mud-fluid or drilling mud) is a mixture of water and clay or shale; it must have a certain consistency and be made up carefully. The clay is derived from alluvial deposits, tertiary, or even older geological formations. Hematite and barytes are used when heavy drilling muds are required, and various chemicals, particularly alkalis, are added to modify the properties of mud to suit the drilling conditions. The weight of mud should not be less than 75 lb./cu.ft. and sometimes exceeds 125 lb./cu.ft. (specific gravity 2.0). The manufacture of mud and its chemical treatment are described in detail. Seven references. M.H.

Sand classifier. A. L. Curtis. *Sands, Clays & Minerals*, **2** [4] 153–59 (1936).—The problem of removing clay substances, silt, organic matter, and other impurities from sands in preparation for use in the various industries, the methods used for washing and grading, and equipment are reviewed. M.H.

Self-operating temperature controller. Yarnall Waring Co. *Instruments*, **9** [3] 59 (1936).—Supplementing the automatic gas valves for temperature control in gas-fired industrial appliances, a corresponding $^1/_2$-in. control valve is announced for steam-heat equipment. It is of the throttling type, with bulb-and-bellows thermal system. The valve body is of cold rolled steel, disk and seat of Monel, stem of Tobin bronze, and bonnet of brass, with asbestos-graphited packing in the stuffing box. This control is used on the outlet end of a steam heating coil to handle condensate, but may also be used on the inlet end. It is suitable for steam pressures up to 125 lb./sq. in. R.W.R.

Training instrument men where instruments are made. R. C. Kennan. *Instruments*, **9** [4] 109–11 (1936).—The Brown Instrument Co. presents courses in the maintenance of various instruments, at nominal cost, for instrument men and supervisors from other companies. R.W.R.

Transport problems in clayworks. J. W. White. *Claycraft*, **9** [6] 265 (1936).—Effective methods of reducing production costs of brick manufacture are discussed. Overhead-chain haulage requires a high installation cost, is inefficient, and involves man labor at both ends of the system. Locomotive haulage gives irregular clay feeding to the mill. Wire-rope haulage is widely used and, when properly installed with automatic grippers, has proved fairly efficient. Where there is considerable distance between mill and clay deposit the aerial ropeways seem to be the most efficient and automatic. These are (1) the monocable and (2) double-rope system. For automatic working throughout, the latter appears to be the most efficient. M.C.S.

Two-stage oil-diffusion pump. J. E. Henderson. *Rev. Sci. Instruments*, **6** [3] 66–67 (1935).—A two-stage oil-diffusion pump built of glass is described which makes possible the use of oil without requiring an unusually good coarse vacuum. The novelty of the pump lies in the first stage which is so designed that it cannot clog even with the small clearances needed to work against high pressures. H.E.S.

Use of the spectrograph in industry. H. W. Lohse. *Sands, Clays & Minerals*, **2** [4] 133–41 (1936).—Principles of spectrometry, methods for application in industrial routine purposes, and apparatus are described. Tables of flame spectra and analyses of minerals and solutions are added. Fifteen references. M.H.

Wear-testing machine. Riehle Division, American Machine and Metals Mfg. Co. *Instruments*, **9** [3] 59 (1936).—This apparatus is designed to simulate practical conditions of friction and wear between two nonlubricated surfaces, *e.g.*, wear of rails and car wheels. Friction qualifications are determined by measuring the amount of metal removed through wear at various speeds and loads. The two wear-test specimens are approximately 2 x 1 x $^1/_2$ in. One is held rigidly in a slide, the other in a gripping head connected to the loading mechanism. The maximum stroke is 1 in., secured by means of an eccentric shaft connected to a variable-speed drive and a two-speed motor, so that speed can be regulated between 25 and 300 double strokes per min. The load may be varied between 20 and 2000 lb. R.W.R.

BOOK AND BULLETIN

Charts for determining the performance of centrifugal fans. G. E. McElroy. *Bur. Mines Rept. of Invest.*, No. 3298, 30 pp. Free. The report presents types of charts adapted to aid in graphic solution of fan-performance problems of selection and operation. R.A.H.

Cryptol Electric Furnaces. A. S. Bazilevich. Chief Ed. Office Bldg. Ind., Moscow, 1935. 68 pp. Price 1R 50k. In general the brochure contains nothing new. S. I. Perkal

PATENTS

Machine for making brick, etc. W. G. Chapman and Dunns' Engineering Works, Ltd. Brit. 445,014, April 16, 1936 (Oct. 24, 1935).

Machine for the surface marking or treatment of brick, etc., when in the plastic state. H. Sutcliffe and G. Hearth. Brit. 445,216, April 22, 1936 (Dec. 21, 1934).

Melting and holding furnace. J. G. G. Frost (National Smelting Co.). U. S. 2,040,787, May 12, 1936 (May 18, 1931). U. S. 2,040,788, May 12, 1936 (June 6, 1932).

Solid lubricant. G. R. Taylor and R. N. Smith (McColl-Frontenac Oil Co., Ltd.). U. S. 2,038,689, April 28, 1936 (July 10, 1933). A solid dehydrated lubricating compound for locomotive driving journals comprises from 30 to 45% sodium soap, from 3 to 15% calcium soap, from 3 to 15% aluminium soap, less than 1% water, and from 1 to 5% glycerine, the balance of the compound being constituted by highly viscous naphthenic oil characterized by a viscosity index of 0 to 30.

Kilns, Furnaces, Fuels, and Combustion

Air cleaning in coal preparation. R. G. LAWRY. *Proc. Ill. Mining Inst.*, pp. 37–39 (1935). A.H.E.

Art of cleaning coal. EDWARD O'TOOLE. *Proc. Ill. Mining Inst.*, pp. 74–78 (1934). A.H.E.

Carbonization of coal. Effects of variation of heating rate during carbonization of a typical coking coal. W. B. WARREN. *Ind. Eng. Chem.*, **27** [11] 1350–54 (1935).—Results are reported on a series of experiments on the carbonization of a typical coking coal in which the rate of heating was changed at various temperatures during each run. The object of the work was to determine whether the effects noted in previous studies, *i.e.*, increase in yield of tar and decrease in yield of coke as rate of heating over the whole range was increased, could be related directly to the rate of heating through any particular temperature interval. Three series of carbonizations were made to a maximum temperature of 700°C in which two rates of heating, 1.4° and 21.8°C/min., were used in several combinations. The data show that the heating rate through the preplastic range is important in determining the yields of carbonization products and gas composition. Coke hardness, on the other hand, is determined largely by the rate of heating through the plastic range. In general, W. concluded that theories to explain the processes of carbonization can not be built up about the plastic range alone, since quite as important events occur both below and above it. See *Ceram. Abs.*, **14** [11] 287 (1935). F.G.H.

Cleaning or betterment of Illinois coal by the dry method. EDWARD O'TOOLE. *Proc. Ill. Mining Inst.*, pp. 42–46 (1935). A.H.E.

Cleaning of Illinois coal. JOHN GRIFFEN. *Proc. Ill. Mining Inst.*, pp. 33–36 (1935). A.H.E.

Coal of the Pikes Peak region. Evolution of gases during low-temperature carbonization. F. W. DOUGLAS. *Ind. Eng. Chem.*, **28** [2] 219–22 (1936).—Low-temperature carbonization characteristics of some sub-bituminous Colorado coals are described in detail. Illustrated. F.G.H.

Coal processing plant of the Binkley Coal Co. W. E. RUTLEDGE. *Proc. Ill. Mining Inst.*, pp. 103–106 (1934). A.H.E.

Coal utilization (with special reference to sulfur content). W. D. LANGTRY. *Proc. Ill. Mining Inst.*, pp. 136–43 (1935). A.H.E.

Coal washing in Baum-type washers with selective ash control. J. W. WILSON. *Proc. Ill. Mining Inst.*, pp. 39–42 (1935). A.H.E.

Coking coal, its nature and synthesis. BALARAM SEN. *Quart. Jour. Geol., Mining & Met. Soc. India*, **1** [3–4] 135–45 (1928).—From study of a series of coal samples from Jharia, S. concludes that (1) the coking value of a coal is not dependent on its ash, volatile matter, or fixed carbon content, but is due to a resinous substance in the coal which can be extracted by a suitable solvent; (2) the coal so treated loses its coking power to an extent depending on the degree of extraction; (3) poor coking coals can be made to coke by the judicious addition of pitch or other suitable bond; and (4) increase of volatile matter in a coking coal results in lowering its coking value, *i.e.*, high volatile coals will have poor coking values. A.P.S.

Control of firing in the ceramic industry. FAUSTO POZZI. *Corriere Ceram.*, **14**, 235–37 (1933); *Chem. Abs.*, **28**, 4555 (1934).

Dew-point of flue products from manufactured-gas combustion. J. S. YEAW AND L. SHNIDMAN. *Ind. Eng. Chem.*, **27** [12] 1476–79 (1935).—The experimental results for the dew-points of the flue products resulting from the combustion of the manufactured gas show that the true dew-points are higher than those calculated from the water estimated to be present (according to the chemical equations involved in the combustion) by an increasing amount as the excess air in these gases decreases. The difference is about 18°F (10°C) at the point of theoretical combustion with no excess air. A consideration of the vapor pressures of the various constituents of flue gases indicates that this deviation can be taken to represent the effect of the presence of a trace of sulfur trioxide in the flue products resulting from the combustion of 9 grains of sulfur per 100 cu. ft. of the manufactured gas. Illustrated. F.G.H.

Evaluation of washed coal. DAVID R. MITCHELL. *Proc. Ill. Mining Inst.*, pp. 51–55 (1935). A.H.E.

Fundamentals of coal cleaning. HENRY F. HEBLEY. *Proc. Ill. Mining Inst.*, pp. 123–35 (1935). A.H.E.

Heat and clay. CHARLES HILL. *Claycraft*, **9** [3] 116 (1935).—A fundamental and general discussion of the drying and firing of clay is given. See *Ceram. Abs.*, **13** [8] 217 (1934). M.C.S.

Kindling properties of coke. Ignition temperature of coke and air required to support combustion. C. R. HOLMES AND J. D. DAVIS. *Ind. Eng. Chem.*, **28** [4] 484–88 (1936).—Kindling properties of cokes and their draft requirements, as measured by methods described, vary with the carbonizing temperature at which the coke is made and with the grade of coal used. Illustrated. F.G.H.

Oil firing in revolving and other types of furnaces. RUDOLF WITTE. *Tonind.-Ztg.*, **59** [103] 1261–62; [104] 1274–76 (1935).—The use of fuel oil for firing furnaces and various types of burners are discussed. Illustrated. M.V.C.

Preparation of coal at Delta Coal Company, Illinois. MERL C. KELCE. *Proc. Ill. Mining Inst.*, pp. 55–60 (1935). A.H.E.

Prevention of gas explosions by controlling oxygen concentration. G. W. JONES AND R. E. KENNEDY. *Ind. Eng. Chem.*, **27** [11] 1344–46 (1935).—An investigation of the values below which the oxygen must be maintained to prevent explosions of combustible gases and vapors is described. Elevated temperatures cause a widening of the inflammable limits of combustible gases and vapors and therefore a decrease in the oxygen concentration necessary to prevent flame propagation. The oxygen content of combustible mixtures containing either carbon monoxide or hydrogen or both should not exceed 5% if explosion hazards are to be eliminated. F.G.H.

Problems in the design of coal-cleaning plants. BYRON M. BIRD. *Proc. Ill. Mining Inst.*, pp. 149–60 (1934). A.H.E.

Process of firing brick. ERNEST HELD. *Tonind.-Ztg.*, **59** [88] 1091–92 (1935).—H. deals chiefly with the process of fuel combustion. M.V.C.

P-V-T relations of gaseous mixtures. E. R. GILLILAND.

Ind. Eng. Chem., **28** [2] 212–15 (1936).—The slope of the isometric of a mixture can be calculated by the molal average of the slopes of the isometrics of the pure constituent gases, all measured at the same molal concentration. This rule, together with a method for estimating the internal pressure, furnishes a means of predicting the P-V-T properties of the mixture. For the three gaseous mixtures given, the agreement with the experimental data is better than either Amagat's or Dalton's laws and is probably within the experimental error of the data. F.G.H.

Rôle of moisture contents in Indian coking coals. BALARAM SEN. *Quart. Jour. Geol., Mining & Met. Soc. India*, **1** [3–4] 147–49 (1928).—Moisture content in a coal may be taken as an approximate index of the coking property in a coal. A.P.S.

"Sherlock" Econo kiln. H. BYRON. *Claycraft*, **8** [11] 478 (1935).—This kiln has 32 chambers in a continuous tunnel formation; each chamber has a capacity of 15,000 brick, and on the schedule now followed 60,000 brick per day are produced, which is the minimum output for the kiln. An outstanding feature of this kiln is the construction of a "steam flue" outside of the batter wall through which a larger volume of air than usual is drawn from the cooling and drying chambers. M.C.S.

Solid carbon reactivity. New method of interpreting reactivity data. C. C. FURNAS. *Ind. Eng. Chem.*, **28** [4] 498–502 (1936).—F. proposes to measure reactivity in terms of the reaction-rate constants for the equations (*A*) $C + O_2 = CO_2$ and (*B*) $CO_2 + C = 2CO$. In other words, reactivity consists of two distinct entities and can not possibly be defined by a single constant, for the rate of reaction (*A*) has no direct connection with the rate of reaction (*B*). By starting with the differential equations of the rates of these reactions and making a few assumptions, F. develops a simple method for obtaining approximate rate constants for reactions (*A*) and (*B*). It is necessary to know only the maximum percentage of carbon dioxide and its position in the bed for a solid fuel being burned with air. The reaction-rate constants are computed from fuel-bed data already in the literature. The tabulation of the data brings out many interesting comparisons between various fuels. F.G.H.

Three hundred years of American fuels. A. C. FIELDNER. *Ind. Eng. Chem.*, **27** [9] 983–88 (1935).—Developments and trends in the use of fuels are chronologically discussed and policies for fuel conservation are suggested. Illustrated. F.G.H.

Tunnel kilns; the Sovereign Potteries installation. J. T. ROBSON. *Clay Prod. News*, **9** [3] 5 (1936).—A comparison of straight and circular tunnel kilns is given with a description of the circular tunnel-kiln installation at the Sovereign Potteries, Ltd., Canada. M.C.S.

Types of kilns of the brick industry. ANON. *Tonind.-Ztg.*, **59** [89] 1101–1102; [90] 1115–17; [91] 1129–30; [92] 1140–41; [93] 1152–54; [95] 1175–77; [96] 1190–91; [101] 1234–36 (1935).—Various German brick firing kilns are described. Illustrated. M.V.C.

Volatile matter of Pennsylvania anthracite. H. G. TURNER AND W. L. KEENE. *Ind. Eng. Chem.*, **27** [11] 1373–76 (1935).—The composition of the volatile matter of Pa. anthracite was determined by treatment of 36 bed samples selected from points throughout the anthracite region. The proximate and ultimate analyses for the samples used and the proximate analyses for prepared coals from all parts of the region are given. The samples tested were heated slowly at temperatures from 70° to 1900°F (21° to 1036°C) in a nichrome tube connected to 12 or 15 liters of space evacuated to less than 1 mm. pressure. Hydrogen sulfide appeared in small quantities in every sample of evolved gas. No illuminants were detected. No tar was emitted by any of the coals. The gas contained 75 to 89% hydrogen (average 83%); the average volume of hydrogen was about 5000 cu. ft./ton of coal under standard conditions. Illustrated. F.G.H.

BULLETINS

Check determinations of grindability of coal by various methods. W. A. SELVIG. *Bur. Mines Rept. of Invest.*, No. 3301, 16 pp. Free. S. describes tests conducted under the subcommittee on Coal and Coke of the A.S.T.M. with a view to evaluating various laboratory procedures for testing grindability of coal. R.A.H.

Firing defects, their cause and removal (Brennfehler, ihre Ursachen und Beseitigung). A. HIELSCHER. Tonind.-Ztg., Berlin. 36 pp. Price 1.25 Rm. Reviewed in *Tonind. Ztg.*, **59** [102] 1254 (1935); for abstract see *Ceram. Abs.*, **14** [11] 288 (1935). M.V.C.

PATENTS

Muffle furnaces. BONNYBRIDGE SILICA & FIRECLAY CO., LTD., AND W. MCBRYDE. Brit. 445,972, May 6, 1936 (Feb. 5, 1935).

Tunnel kiln. C. H. PARMELEE (Onondaga Pottery Co.). U. S. 2,039,445, May 5, 1936 (April 20, 1935). The combination in a continuous tunnel kiln having a horizontal elongated chamber and a bottom wall for the chamber comprising two or more longitudinally extending portions, each separated from another of the portions by a longitudinally extending bottom wall slot and the upper side of each of which provides a stationary supporting surface, of a vertically and longitudinally reciprocating goods advancing structure including a beam portion working in each such slot, the upper side of each such beam portion forming a movable supporting surface moved between a position above and a position below the stationary surface when the structure is raised and lowered, the stationary and movable surfaces coöperating for the step by step advancement of goods through the chamber, and one or more kiln heating units, each comprising an elongated combustion chamber formed in one of the portions and horizontally intermediate of those portions of the slot or slots which are respectively adjacent to the opposite sides of the first-mentioned chamber, and means for supplying fuel and air for its combustion to and for withdrawing products of combustion from the combustion chamber.

Geology

Analytical notes on white earths and pigments. W. R. SCHOELLER. *Sands, Clays & Minerals*, **2** [4] 73–80 (1936).—Qualitative and quantitative methods of determination for materials in a fine powdery state are described for carbonates, quicklime, calcium sulfate, oxides, sulfates, titania, alumina, zirconia, and silicates. M.H.

Ceramic raw materials in Canada. V. CHARRIN. *Verre & Silicates Ind.*, **7** [8] 96–97 (1936).—All the minerals used in ceramics and their principal deposits and production figures in the Dominion are reviewed in a booklet published in French by the Minister of Mines at Ottawa. M.V.C.

China clay deposits of Ajmer-Merwara. K. K. SEN GUPTA. *Quart. Jour. Geol., Mining & Met. Soc. India*, **3** [4] 171–82 (1932).—A deposit at Ajmer-Merwara, Rajputana, is described. It is derived from the decomposition of a coarse-grained gneiss; another deposit is derived from amphibolites or epidorites, the first of its kind observed in India. The former is an ideal clay except for spangles of mica which leave fine spots in the fired goods and are detrimental in fine pottery. The latter deposit has an analysis of SiO_2 42.88%, Al_2O_3 38.87%, H_2O 14.92%, total alkalis 1.20%, and Fe_2O_3 trace, and is suitable for fine pottery. A.P.S.

Clay for stoneware. FERRUCCIO PALAZZI. *Centro Studi Ceram.*, **2** [9–12] 99–100, 111 (1935).—Samples of clay from Italian quarries were examined and the clay seems to be suitable for stoneware and soft whiteware. M.V.C.

Constitution of the clay minerals. C. E. MARSHALL. *Sci. Progress*, **30** [119] 422–33 (Jan., 1936).—Research on the clay-minerals group during the past 10 years, especially since 1930, in three laboratories has revealed structural features, such as lattice expansion with increasing water content, which are unique in mineralogy. The work in the U. S. of Ross, Kerr, Shannon, Lassen, Steiger, Hendricks, Fry, Kelley, Dore, Brown, Pauling, and Gruner, in England of Mellor, and on the Continent of Nagelschmidt, Hofmann, Endell, Wilm, and Mehmel, is reviewed. H.H.S.

Dead Sea, a storehouse of chemicals. M. A. NEVOMEYSKY. *Iron & Coal Trades Rev.*, **132** [3551] 533 (1936).—Analysis of the water at the surface and different depths is given, the main constituents being KCl, NaCl, $MgCl_2$, $CaCl_2$, $CaSO_4$, and $MgBr_2$. Origin of the salts, and geological and geographical conditions are briefly discussed. The total quantities of salts in solution in the water are 2 million metric tons KCl, 1100 NaCl, 22,000 $MgCl_2$, 6000 $CaCl_2$, and 980 million metric tons $MgBr_2$. M.H.

Effect of drying on grain-size distribution of clays. CARL W. CORRENS AND WOLFGANG SCHOTT. *Kolloid-Z.*, **65** [2] 196–203 (1933).—An Oligocene clay, a deep-sea red clay, and a Papendorf diluvial were dried at 105°C and at various humidities and temperatures down to 30°C. In each case coarsening of the grain was observed, greater at 105°C than at 30°C and lower humidity. Clay dried at 105°C and reëxposed to water showed no further change. After treatment for 200 days in a moist atmosphere, the original Oligocene clay coarsened and failed to give up its absorbed water on subsequent drying at 105°C, while the Papendorf clay became finer. This difference in behavior is attributed to different chemical composition. F.P.P.

Extraction of Georgia shale and wyomingite with hydrochloric acid. S. L. MADORSKY AND J. RICHARD ADAMS. *Ind. Eng. Chem.*, **27** [4] 429–31 (1935).—On the basis of the following test, Georgia shale and wyomingite are susceptible to extraction with hydrochloric acid. Assuming an interrupted countercurrent application of hot saturated acid in the ratio of about 2.5 cc. constant boiling acid to 1 g. of 200-mesh mineral, with 3 hr. stirring of the shale and 1 hr. of the wyomingite, an extraction of about 66% alumina, 80% potassium oxide, and 73% ferric oxide could be expected in the shale, and 100% alumina, 85% potassium oxide, and 50% ferric oxide in the wyomingite. The shale would yield a concentrated solution of 50% alumina, 75% potassium chloride, and 20% ferric chloride that could be precipitated with hydrochloric acid. Illustrated. F.G.H.

Geology of the white clay deposits in Siruma Peninsula, Camarines Sur, Luzon. QUIRICO A. ABADILLA. *Philippine Jour. Sci.*, **57** [2] 227 (June, 1935).—A. describes the location, geology, and accessibility of a number of small deposits of white alluvial clay that have been discovered in Luzon, P. I. R.F.R.

Kyanite deposit in Bihar and Orissa. D. C. NAG. *Quart. Jour. Geol., Mining & Met. Soc. India*, **6** [3] vii (1934).—N. discusses the origin, sequence, and condition of formation of associated minerals of a kyanite deposit near Pandra in Pathcomb estate (Manbhum district), extending over an area of $^1/_4$ mile by 1 mile. The deposit is said to be of magmatic origin, and as such, the kyanite is more likely to be found in nature in a sufficiently pure state and a profitably workable condition. A.P.S.

Mineral resources of East Africa, current mining activity and costs. A. K. BENHAM. *Sands, Clays & Minerals*, **2** [4] 115–19 (1936).—Geological and economical conditions of the gold- and diamond-bearing ground are described. M.H.

Minerals for coloring glass and enamels. H. LAITHWAITE. *Sands, Clays & Minerals*, **2** [4] 109–14 (1936).—Some historical data are given. Copper oxides seem to have been used exclusively for coloring in the ancient Egyptian glasses, about B.C. 5000, when almost any color for glasses was already known and produced. The following important coloring agents are reviewed briefly and their chief characteristics described: Cu, Co, Ni, Mn, Cr, Fe, Se, SnO_2, $ZrSiO_4$, Sb_2O_4, TiO_2, $FeTiO_3$, fluorspar, cryolite, and Al compounds. The action of some of these used as decolorizers is explained. M.H.

Mineralization in the pre-Cambrian of the Anti-Atlas. F. BLONDEL AND J. BONDON. *Compt. rend.*, **202** [8] 673–74 (1936).—The origination of Co, Ni, Cr, and Cu in the pre-Cambrian zone of North Africa is discussed on the basis of stratographic investigation. The rôle of quartz in the origin of gold ores is explained. M.H.

Mining on the Gold Coast. J. E. METCALFE. *Sands, Clays & Minerals*, **2** [4] 143–50 (1936).—The geology, geography, and petrography of the country is described with statistics of production of minerals, clays, and sands. Mining methods by the natives are illustrated by photographs. M.H.

Niobium and its uses. L. SANDERSON. *Sands, Clays &*

Minerals, **2** [4] 99–101 (1936).—Nb, one of the rarer elements, is contained in columbite which is an end member of a series of niobates of Fe and Mn; it closely resembles Ta and has a melting point above 1800°C. It is mainly used as electrode material in radio valves and as a "getter" in vacuum tubes; it has a larger electron emission at high temperatures than Mo. When used as an alloying element in steel it is said to render the metal harder and tougher than do other elements, and acts also as a scavenger in a manner similar to V. The metal is produced by reduction from the ore and manufactured into bars, sheets, wires, and rods, but little has so far been produced. The principal compounds are NbH, NbO_2, Nb_2O_4, Nb_2O_5, Nb_2O_6, and NbF_5KF; the specific gravity is 8.3. As a stabilizer of stainless steels, it retards intergranular corrosion, especially after long holding at 1000° to 1500°F.
M.H.

Petrology of the Warren House series, Malvern. J. I. PLATT. *Geol. Mag.*, **70**, 423–29 (1933).—This series is made of pre-Cambrian lavas, now slightly altered.
W.D.F.

Porter Creek clay of Tennessee as a bleaching agent for oils. GEO. I. WHITLATCH. *Oil & Soap*, **13** [2] 38 (1936).—The Porter Creek clay seems to offer a source for bleaching earth, the chief objections being (1) moderately high retention and (2) fat splitting tendencies. See "Bleaching—" *Ceram. Abs.*, **15** [1] 37 (1936). M.C.S.

Potash from polyhalite by reduction process. F. FRAAS AND E. P. PARTRIDGE. *Ind. Eng. Chem.*, **28** [2] 224–30 (1936).—Illustrated. F.G.H.

Potting clays. A. RIGBY. *Trans. Ceram. Soc.*, **34** [9] 381–95 (1935).—R. discusses the mining, processing, and testing of china and ball clays. See *Ceram. Abs.*, **14** [9] 231 (1935). R.H.H.P., JR.

Refractory clays in northern Ontario. ANON. *Can. Mining Jour.*, **57** [3] 140 (1936).—General Refractory Products, Ltd., is developing refractory clay deposits on the Mattagami river. A private railroad will be extended seven miles to reach the operation. See "Mattagami—" *Ceram. Abs.*, **14** [5] 117 (1935); "Fire—" *ibid.*, **15** [2] 72 (1936). G.M.H.

Refractory clays of the Pologi deposits (Ukraine). E. I. ZINDER. *Ogneuporui*, **3** [4] 304–308 (1935).—A description of analyses, properties, etc., is given; the Pologi clays are used in the refractories industry. P.B. & E.S.

Silica. J. H. EMERY. *Clay Prod. News*, **9** [3] 3 (1936).—The silica used in most Canadian porcelain enamel frits is obtained from a deposit at Kasil, P.Q., near Montreal. The ganister obtained from this deposit is crushed and passed through a 10-mesh screen, after which it is treated with a magnetic separator to remove the iron. This material is then pulverized in pebble mills and the dust collected in air separators. The resulting silica has a typical analysis of 99.4% SiO_2, 0.35% Al_2O_3, and 0.03% Fe_2O_3. M.C.S.

Structure of manganite. JULIO GARRIDO. *Anales Soc. Española Fis. Quim.*, **33** [327] 783 (1935).—The structure of manganite (MnO·OH) is determined by means of X-rays. It is orthorhombic with the following dimensions of the unit cell: $a = 4.42$Å, $b = 5.23$Å, $c = 2.87$Å. The coördination number of manganese in manganite is 6.
R.F.R.

Zirconia deposits of Brazil. A. COWNLEY SLATER. *Sands, Clays & Minerals*, **2** [4] 103–107 (1936).—Geographical and geological distribution is described; the deposits are essentially oxide of Zr (zirconia) and are clasified as favas (rounded masses of 90 to 95% ZrO_2) and amorphous. Zr is used in steel, and zirconia is an excellent refractory. Methods of winning and treating the ores are described. M.H.

BOOKS AND BULLETINS

Bibliography of North American geology, 1933 and 1934. E. M. THOM. *Geol. Surv. Bull.*, No. 869. 389 pp. Price 40¢ from Supt. of Documents, Washington, D. C. This is a continuation of the series of bibliographies of North American geology, which covers publications from 1785 to the end of 1934. R. A. HEINDL

Chromite. ROBERT H. RIDGWAY. Reprint from Bur. Mines Minerals Yearbook, 1935. 12 pp. Price 5¢.
R.A.H.

Clay. PAUL M. TYLER AND R. W. METCALF. Reprint from Bur. Mines Minerals Yearbook, 1935. 16 pp. Price 5¢. R.A.H.

Feldspar. R. W. METCALF. Reprint from Bur. Mines Minerals Yearbook, 1935. 6 pp. Price 5¢. R.A.H.

Minor nonmetals: graphite, greensand, kyanite, mineral wool, monazite, olivine, strontium minerals, and vermiculite. PAUL M. TYLER. Reprint from Bur. Mines Minerals Yearbook, 1935. 23 pp. Price 5¢. R.A.H.

White Titanium Oxide (Titanweiss). KURT HEISE. Theodor Steinkopf, Dresden, 1936. 96 pp., 13 illustrations, 27 tables. Price 6.00 Rm. This is the first complete book ever published on titanium oxide, and the text is divided into the following chapters: manufacturing methods, raw materials, patent literature and processes, and use of titanium as a white pigment in the paint industry, and as filler, catalyzer, etc., in other industries. A chapter also deals with the chemical and physical tests.
L. E. THIESS

Chemistry and Physics

Chemical analysis and its problems. G. E. F. LUNDELL. *Crucible*, **20**, 8 (1936).—Analytical chemistry is the foundation of chemical science and will become more important. The older methods of separation are often inadequate as they are not specific enough. Some of the newer organic reagents are better. Spectrographic analysis may some day do most of the routine work. See *Ceram. Abs.*, **12** [10–11] 360 (1933). W.D.F.

Chemical analysis by X-rays. F. P. DWYER. *Jour. Australian Chem. Inst.*, **3** [3] 85–91 (1936).—Three technics available are (1) direct excitation by electron bombardment, (2) analysis of secondary radiation, and (3) determination of absorption limits. By the last method a barium glass was analyzed for Ba in 2 hr. without alteration of the specimen. H.H.S.

Collation of experimental data: XXVI. A. ALISON. *Glass*, **12** [10] 425 (1935).—A. discusses the normal probability curve as a means of recording and interpreting data.

XXVII. *Ibid.*, [12] 510.—An illustration of the increased accuracy to be obtained through multiple determinations of any given set of observations is given. When several check readings are made and the average is taken, the deviation is reduced from the standard deviation obtained with one reading to the dividend of the standard deviation divided by the square root of the number of observations taken. **XXVIII.** *Ibid.*, **13** [1] 18 (1936).—A. discusses the difference in means and methods of determining standard deviations. **XXIX.** *Ibid.*, [2] 68.—Methods of expressing and interpreting data when (1) mean is unknown and the standard deviation is known, and (2) mean and standard deviation are both unknown are given. **XXX.** *Ibid.*, [3] 104.—The method of recording and interpreting data obtained in testing small samples where large errors are likely to be encountered is discussed. **XXXI.** *Ibid.*, [4] 158.—The mathematical term "range" and its application in representing and interpreting data are taken up. For Parts **XXIV–XXV** see *Ceram. Abs.*, **15** [4] 134 (1936).

M.C.S.

Combined reagent for J. Lawrence Smith fusion. S. R. Scholes and V. E. Wessels. *Chemist Analyst*, **25** [2] 38 (1936).—Preparation in advance of the mixed calcined reagent facilitates the fusion of silicates for alkali analysis; 5 g. of prepared reagent is used with 1 g. of powdered silicate. A.P.

Contribution to the knowledge of oxides: VII, Thermal dissociation of γ-Fe_2O_3. A. Simon and A. Landgraf. *Kolloid-Z.*, **74** [3] 296–300 (1936).—Tensiodiometric and X-ray investigation of γ-Fe_2O_3 showed that this material was not noticeably dissociated by heating to 300°C in high vacuum. The dissociation into Fe_3O_4 observed by Girard, Chaudron, and others was traced to the presence of reducing substances (grease, etc.). According to the magnetic measurements, partial transformation of the γ-Fe_2O_3 into α-Fe_2O_3 occurs. Platinum black failed to catalyze the decomposition of γ-Fe_2O_3 at 300°C.

F.P.P.

Determination of small amounts of chromium in titanium oxide. R. Flatt and X. Vogt. *Bull. Soc. Chim.*, **2**, 1985–92 (1935); abstracted in *Analyst*, **61**, 62–63 (Jan., 1936).—Cr, even in small amounts, imparts a yellowish tint to TiO_2. A method is described for determining Cr down to parts per million. H.H.S.

Effect of dissolved air on the specific heat of water over the range of 15° to 20°C. E. O. Hercus. *Proc. Phys. Soc.* [London], **48** [2] 282–84 (1936).—The specific heat of water saturated with air at 20°C under normal atmospheric pressure exceeds that of air-free water by 6×10^{-4} cal./g.

L.E.T.

Effect of heat on clays. G. R. Rigby. *Claycraft*, **9** [7] 313 (1936).—A fundamental discussion of the chemical changes occurring in clays as they are heated and the effect of these changes upon the volume, specific gravity, porosity, and cold crushing strength is given. M.C.S.

Estimating open-hearth slag composition. I. N. Goff. *Blast Fur. Steel Plant*, **22** [11] 640–41; [12] 693–94 (1934).—The metallurgist needs rapid methods of obtaining information about slag compositions to apply them in working or finishing heat properly. Methods suggested as practical for this purpose in the control laboratory include determinations of FeO, Fe_2O_3, MnO, and specific gravity. Complete descriptions of the methods of making these determinations are given with comments on their accuracy. It is suggested that the remainder of the slag composition can be estimated by referring to prepared charts.

E.J.V.

Formation of silicates during firing: I, Review of literature, study of raw materials, and methods. G.V. Kukolev. *Urkrain. Nauchno-Issled. Inst. Ogneuporov & Kislotouporov*, No. 34, pp. 1–23 (1935).—Results are shown in tables and diagrams. **II, Chemical reactions occurring during firing of silica.** V. B. Kraft and L. V. Vinogradov. *Ibid.*, pp. 24–29. **III. Physicochemical changes of properties of silica mixes on firing.** G. V. Kukolev. *Ibid.*, pp. 30–76 (1935).—No free lime could be found at 500°; the mechanical strength of the body is reduced and it becomes friable. Firing to cone 018 is accompanied by a conversion of β-quartz into α-quartz and some increase of mechanical strength. During these firing stages, bicalcium and tricalcium silicates are formed. Firing to cones 05 and 03 produces a sudden change in the color of samples and increases the mechanical strength of the body. Firing to cone 6 causes the incipient transformation of quartz which is small in the case of crystalline quartz and greater in cemented quartzites. Tridymite and cristobalite are formed at this time. The mechanical strength of the body increases greatly. The macrostructure is characterized by a considerable amount of dust-like quartz grains. The firing to cone 10 changes the body considerably. Its specific gravity decreases and the volume increases. The amount of tridymite and cristobalite augments rapidly while the strength of the body decreases. At cone 13 cracks appear; dust-like quartz grains disappear showing that the finer fractions have been converted. The formation of monocalcium silicate increases. Firing to cone 14 intensifies these processes. At cone 16 the degree of transformation greatly increases. Because of strains set up during the growth of the intensively converting quartz, the cracking increases more rapidly than the mechanical strength. The thin sections show a high grade of tridymitization, while the quartz grains are covered with a network of cracks. The amount of monocalcium silicate crystals decreases, while the remaining quartz grains are cemented by the ground mass. The conclusions are as follows: (1) The firing rate of silica can be accelerated considerably, especially in temperature ranges lower than 550°C and from 600° to cone 10. (2) At higher temperatures, and especially at temperatures higher than cones 13 or 14, the firing must proceed slowly and carefully to avoid cracks. M.V.C.

Friction and adhesion: III, Friction on mica surfaces. B. Derjaguin and W. Lazarev. *Kolloid-Z.*, **69** [1] 11–16 (1934).—The coefficient of friction between freshly cut mica surfaces was found by measuring the angle at which a given pressure caused sliding of one surface. The relation between load and force of friction was linear; for short periods the coefficient was about 1, but repeated tests produced lower values, owing to accumulation of surface dirt. Water lowered the coefficient to 0.2, and NaOH solution lowered it to 0.18, although with good lubricants the decrease was less than with water. Le Chatelier's clay plasticity theory was confirmed, *i.e.*, that water reduces friction between leafy crystallites permitting plastic deforma-

tion. **IV, Theory of adhesion of small particles.** B. DERJAGUIN. *Ibid.*, [2] 155–64.—D. presents a mathematical derivation of a theory of adhesion of solids based on the attractive forces for undeformed materials and for deformed contact surfaces. In the absence of deformation, the adhesive force of convex bodies is proportional to the work involved per unit area in separating flat surfaces. Repulsion is possible, depending on the lyosorption properties, if the intersolids phase is considered. F.P.P.

Influence of viscosity variation on rupture of plastic bodies. R. K. SCHOFIELD AND G.W. SCOTT BLAIR. *Nature*, **136** [3430] 147 (1935).—The authors define viscosity as the ratio of the shearing stress in any plane to the rate of shear or velocity gradient perpendicular to the plane. This viscosity is always a variable for solids, its value depending particularly on the magnitude of the shearing stress. The importance of the degree of variability of viscosity in relation to the rupture of plastic solids is emphasized. A golden syrup falling from a tube 10 to 20 cm. long and 1 cm. in diameter runs in a continuous stream. A clay paste falls from the tube in "blobs." Since the surface tension is about the same in both cases the difference in behavior must be due to viscosity differences. It is not a question of absolute magnitude of the viscosities since these can be changed considerably by altering the concentrations without making the two materials act alike. Apparently, the difference lies in the fact that the viscosity of the sugar syrup is independent of the stress while that of the clay paste varies greatly, particularly near the yield value. Soft soap, which has a variable viscosity not as steeply variable as that of clay paste, forms "blobs" which do not completely separate if they do not fall too far. There are indications that shortness in flour dough is associated with a particularly rapid decrease of viscosity with increase in shearing stress. It is suggested that the rate of decrease of viscosity of metals with increase in shearing stress may be a determining factor in their tensile strength. There may be a general connection between the the manner of rupture and the degree of variability of viscosity even though the underlying mechanism is different for different kinds of materials. In practice, the effect may be obscured by factors other than shearing stress as in the case of heather honey. If kept overnight in the tube this honey sets to a thixotropic gel which falls in "blobs." If stirred it runs in a stream like the syrup. Flour dough strain-hardens on extension. Rubber in benzene differs from both syrup and clay pastes because it has a much longer relaxation time (ratio of viscosity to rigidity modulus). Such factors complicate the problem but do not invalidate the postulated relationship between degree of variability of viscosity and manner of rupture.

J.L.G.

Investigation of the viscosity of suspensions and solutions: I, Suspensions. E. GUTH. *Kolloid-Z.*, **74** [2] 147–72 (1936).—A review of current theories of viscosity of suspensions and of experimental verifications, with especial reference to the theory of electroviscosity, is given. The effect of particle size and shape on viscosity is discussed. **II, Theory of electroviscosity.** W. KRASNY-ERGEN. *Ibid.*, pp. 172–78.—The work of Einstein, Smoluchowski, etc., is reviewed and it is shown that the formulas of S. show excellent agreement with experimental values for relatively good conductors, but are without validity for insulators. **III, Viscosity of globular suspensions.** E. GUTH AND R. SIMHA. *Ibid.*, [3] 266–75.—Calculation of the influence of the apparatus wall on a rotating globule shows it to be smaller than on a translatorly moving globule, in agreement with the findings of Przibram. The influence of apparatus wall on a globule in a sheer dilatation current and a wall-influence correction for Einstein's law are calculated. The reciprocal effect of two rotating globules is established. **IV.** F. EIRICH, M. BUNZL, AND H. MARGARETHA. *Ibid.*, pp. 276–85.—Investigation verified the validity, for systems properly constituted, of Einstein's hydrodynamically evolved equation and offered further indications of the independence of viscosity of finely divided globular suspensions on the degree of dispersion and the type of flow. **V, Influence of Brownian movement on the viscosity of ellipsoid suspensions.** E. GUTH. *Ibid.*, **75** [1] 15–20 (1936).—A critical review of the literature and appraisal of our present knowledge of the influence of Brownian movement on ellipsoid suspension viscosity are given. **VI, Viscosity of acicular suspensions.** F. EIRICH, H. MARGARETHA, AND M. BUNZL. *Ibid.*, pp. 20–37.—The increase in viscosity of a liquid, induced by the presence of suspended long ellipsoids without Brownian movement, is shown to cover a wide range of values. Effects of particle orientation and interlocking, concentration, motion factors, and apparatus wall-influence are examined and discussed and are offered as possible causes for the failure of results to fall within the limits imposed by theory.

F.P.P.

Kinetics of some reactions of interest to ceramists. C. C. FURNAS. *Jour. Amer. Ceram. Soc.*, **19** [6] 177–86 (1936).

Micro-estimation of zinc in the presence of iron, aluminium, uranium, beryllium, and titanium. PR. RAY AND M. K. BOSE. *Mikrochemie*, **18** [1] 89–91 (1935).—The use of quinaldinic acid as a micro-reagent for the estimation of zinc in the presence of various metals and non-metals, *viz.*, Mn, As, P, Ca, Sr, Ba, Mg, Fe, Al, U, B, and Ti, is pointed out. The procedure is described and results of some analyses are given. L.E.T.

Plastometric investigation of substances of high viscosity: I, Plastometer design. GEORG UNGAR. *Kolloid-Z.*, **69** [1] 30–35 (1934).—A plastometer is described consisting of a semispherical container in which a rotor is propelled by a falling weight, various sizes of rotor being available. Advantages claimed are the laminar flow of the thick substances and the possibility of calculating the apparatus factor with simple equations. With dextrin solutions a viscosity of 1153 poises was obtained by U.'s method as against 1194 by the capillary method. For liquids of viscosity between 10^2 and 10^4 poises, shear force to shear velocity ratios can be determined to $\frac{1}{2}\%$ and absolute viscosity to within 2%. The apparatus is suitable for a 10^1 to 10^8 poise viscosity range. **II, Use of the semispherical plastometer for determination of shear curves and calculation of absolute shear constants.** *Ibid.*, [2] 164–72.—Because of their irregular flow at low shear velocities, potter's clay, glass cement, and fat can not be satisfactorily investigated by U.'s apparatus, although yield values can be determined for clays with moisture content in excess of 30%. Suspensions with low yield values, giving *G-U* curves, may be obtained by suspending the solids in starch

sirup. Where G is the load and U the reciprocal of the time, the G-U curves become asymptotic at the origin and at a high value of G, and from the ratio of the slopes of the two asymptotes and the apparatus factor the shear constant is calculable. **III, Determination and evaluation of velocity distribution curves.** *Ibid.*, **70** [3] 277–80 (1935).—Velocity distribution was determined by comparing photographs (taken before and after rotation) of the surface of the substance, on which lines were impressed in a radial direction. The distribution on the photograph, in polar coördinates, may be transformed to a rectangular plot and graphically differentiated. **IV, Determination and evaluation of shear curves of clay slips.** *Ibid.*, **71** [1] 16–22 (1935).—U.'s semispherical plastometer is not entirely satisfactory for some clay slips because of the presence of gliding surfaces within the deformed mass. A shear curve may be obtained, however, if a small amount of starch syrup or dextrin be added. Clay slip should be stirred to prevent aging, and drying of the slip must be avoided. Yield value decreases with increasing water content of the slip. F.P.P.

Precision lattice constants from X-ray powder photographs. M. U. Cohen. *Rev. Sci. Instruments*, **6** [3] 68–74 (1935).—A general method is given for the calculation of lattice constants from powder photographs in which various systematic errors, film shrinkage, absorption, eccentricity, and finite slit height are considered. While the solution of the data is made by least squares, it is not laborious and is simpler than the various methods, both analytical and graphical, which have previously been proposed. Examples are given of cubic, hexagonal, and orthorhombic structures solved in this way using data from Debye and focusing cameras, extension to other structures and cameras being made evident. In effect, powder cameras become absolute instruments, independent of calibrating substances and dependent only on the value of the X-ray wave-length. H.E.S.

Quantitative separation of Cr, Al, Fe, and a complete analysis of chromite. K. N. Todorović and V. M. Mitrović. *Bull. Soc. Chim. Roy. Yougoslavie*, **5**, 219–27; abstracted in *Chem. Zentr.*, **i**, 2981 (1936).—Chromite (0.2 to 0.3 g.) is fused for 2 or 3 hr. with a mixture of borax and K–Na–carbonate in a Pt crucible. The melt is dissolved in water and then treated as usual without evaporating to dryness, as when using Na_2O_2. Cr is determined in the precipitate after dissolving it with HCl. M.V.C.

Quantitative spectrum analysis: I. W. van Tongeren. *Chem. Weekblad*, **33** [9] 130–41; [10] 151–59 (1936).—The historical development, principles of spectrum-analytical methods, apparatus used, and application to methods of quantitative spectrum analysis are described, and several examples are illustrated. M.H.

Rapid method of chemical analysis of clays, kaolins, feldspars, and aluminosilicates. R. I. Boroditzkaya. *Trudui Vsesoyuz. Nauchno-Issled. Inst. Keram.*, No. 46, pp. 1–25 (1935); see *Ceram. Abs.*, **14** [2] 51 (1935). M.V.C.

Spectrographic analysis. H. V. Churchill. *Crucible*, **20**, 54 (1936).—Rapid and accurate quantitative spectrographic methods can frequently be developed to replace laborious and uncertain chemical methods. Each user must develop his own technique. A highly skilled physicist is not necessary; an analytical chemist can do the work. The present method is used chiefly for determining low percentages, but the determination of high percentages is not necessarily excluded. W.D.F.

Systematic packing of spheres, with particular relations to porosity and permeability: I–II. L. C. Graton and H. J. Fraser. *Jour. Geology*, **43** [8, Part 1] 785–909 (1935).—In Part I geometrically systematic arrangements of uniform spheres are investigated. The disclosed relationships are treated as underlying principles of porosity and permeability. Unit voids of six cases of simple systematic packing are explored as the keys to porosity and permeability. The most stable case of packing appears to to be the "tightest or rhombohedral," but the most common natural packing is this type "strewn in a surrounding mesh of haphazard packing." In Part II, permeability in all its relations to porosity is considered. The effects of geometry of intersphere voids and of assemblage orientation on fluid flow is discussed. Permeability can not be exactly computed and must be determined experimentally. Enormous differences in permeability are caused by differences in packing, including effects of container walls and of included larger units. A.C.B.

Temperature dependence of dissolving rate of wollastonite in sodium silicates. O. K. Botvinkin and A. A. Gurevich. *Mon. Phys. Phys.-Chem. Glass* [Moscow], 34 (1933); abstracted in *Sprechsaal*, **68** [52] 799 (1935).—The solubility of synthetic wollastonite in pure glass was investigated; the glass composition was $Na_2Si_2O_5$ + 0.7 SiO_2 and corresponded to the eutectic mixture according to Morey and Kracek. Three grams of powdered wollastonite were added to 20 g. melt of sodium silicate. The crucible was heated at a constant temperature. The results were as follows:

Time of complete dissolving (min.)	Temperature (°C)
1400	1035
600	1125
300	1162
120	1210
60	1240
30	1260

The following formula for the dissolving process is suggested: $\log t = A - B \log T$; where t = time of complete dissolving in minutes, T = "absolute" temperature, and A and B are constants depending on the dissolving mediums and material to be dissolved. In this case A = 100,647; B = 31,100. M.V.C.

Theoretical diffraction patterns corresponding to some simple types of molecular arrangement in liquids. J. A. Prins and H. Petersen. *Physica*, **3** [3] 147–53 (1936). Theoretical patterns are computed for liquid arrangements corresponding to (1) cubic and hexagonal close packed (inert gases, mercury), (2) body-centered cubic (alkali metals), (3) simple cubic (antimony), and (4) diamond structure (silica and water). The diamond structure, with coördination number 4, is identical with the arrangement of Si atoms in cristobalite and is exemplified by amorphous silica, where Warren shows that the cristobalite arrangement gives the best fit. C.J.P.

Theories of the structure of matter and their relation to the resistance of materials. Actual position of atomic

physics. A. MERCIOT. *Rev. mat. constr. trav. pub.*, No. 313, p. 255 (1935).—The analyses of the phenomena which belong to different domains of atomic physics, given by L'Hermite (*Entreprise Française*, Oct. 25, 1935), lead to a more perfect understanding of the structure of matter and the resistance of materials. M.V.C.

Theory of a plastic flow of mineral suspensions. V. K. NIKIFOROV. *Zhur. Fiz. Khim.*, **6** [1] 92–94 (1935).—The dependence of the viscosity of clay suspensions on time is demonstrated and an equation of viscosity is given as $\eta = \eta_0 + \alpha t$ (where t = time, η and η_0 = viscosity after period t and initially, and α = a constant value, depending on the nature of the clay characterizing the activity of swelling). This equation is applicable to solutions containing not more than 45% of mineral matter. In higher concentrations the relations are more complicated. The Bingham equation in its usual form is not applicable to clay suspensions. A somewhat modified equation is given: $\frac{F}{S} - D = (\eta_0 + \alpha t)\frac{dv}{dy}$ and the possibility of substituting D by $f(t)$ is indicated (where $\frac{F}{S}$ = tension of shifting, D = breaking point of shifting, η = coefficient of internal friction, and $\frac{dv}{dy}$ = velocity gradient).

P.B. & E.S.

Viscosity and plasticity of disperse systems: I, Determination of plastic flow constants of clay suspensions. M. P. WOLAROWITSCH AND D. M. TOLSTOI. *Kolloid-Z.*, **70** [2] 165–74 (1935); see *Ceram. Abs.*, **13** [10] 275 (1934). **II, Plastic properties of dough by the rotating cylinder method.** M. P. WOLAROWITSCH AND K. I. SAMARINA. *Kolloid-Z.*, [3] 280–85.—Using a well-stirred suspension of flour in water, Bingham's theory of plastic flow is confirmed for 4 flours. The difference in plasticity of various flours is related to their ability to combine with water. **III, Plastic properties of resin soaps.** M. P. WOLAROWITSCH. *Ibid.*, **71** [1] 22–28 (1935).—Results of determining the flow velocity of resin soaps by two methods indicate Θ to be a physical constant independent of apparatus dimensions but dependent on temperature and water content. **IV, Plastic-viscous properties of molten slags and rocks.** M. WOLAROWITSCH. *Ibid.*, [2] 159–65; see *Ceram. Abs.*, **13** [10] 253–54 (1934). **V, Plastic-viscous properties of peat.** M. P. WOLAROWITSCH, N. N. KULAKOFF, AND A. N. ROMANSKY. *Kolloid-Z.*, [3] 267–74.—Two peats were investigated with a modified capillary viscometer, and within the limits of experimental error the results were in agreement with Bingham's theory of plastic flow. The viscosity and flow resistance were considerably higher for the peat containing more water. Gliding along the tube walls was small for glass but large for iron tubes, in agreement with the measurements of the contact angles. Anomalies in the turbulent flow of the peats were observed similar to those reported by Ostwald. F.P.P.

Wetting-hysteresis as limited by disperavity. I. R. KLJATSCHKO. *Kolloid-Z.*, **74** [1] 90–97 (1936).—The hysteresis of "disperse" wetting is investigated, methods of measuring it are described, and the isotherms are plotted. The relationship between disperse hysteresis and flotation is established. F.P.P.

X-ray reflectivity and resolving power of the (10.0) planes of etched quartz crystals. L. G. PARRATT. *Rev. Sci. Instruments*, **6** [4] 113–15 (1935).—The principal advantage for X-ray spectrometry of quartz crystals cut parallel to the (10.0) planes lies in the relatively large grating space, making the crystals applicable to studies of wave-length in the range of 5 to 8 Å. Data on a second set of grating planes of supposedly "perfect" quartz for use in checking the theories of crystalline reflection were obtained. Good agreement has been obtained between the Darwin-Ewald-Prins theory and experimental values for "perfect" calcite crystals. H.E.S.

BOOKS

Equilibrium Diagrams of Silicate Systems. F. P. HALL AND H. INSLEY. Translated from the English. Edited by G. YU. ZHUKOVSKIĬ. Assn. Sci. Research Inst. Silicate Ind., Moscow, 1936. 128 pp. Price 5R 25k. See *Jour. Amer. Ceram. Soc.*, **16** [10] 455–68 (1933). P.B. & E.S.

***O*-oxyquinoline "Oxin"** (Das O-Oxychinolin "Oxin"). RICHARD BERG. Ferdinand Enke Verlag, Stuttgart, 1935. 94 pp. Price 8.80 Rm. Reviewed in *Sprechsaal*, **68** [51] 788 (1935).—The application possibilities of "oxin" or *o*-oxyquinoline for scientific and technical purposes are discussed. Exact analysis methods for determining and separating twenty-five elements are described. Many of these methods can be used successfully in ceramic and glass analyses. M.V.C.

PATENTS

Process for the production of lithium salts. HANS SIEGENS AND OSKAR RODER (American Lurgi Corp.). U. S. 2,040,573, May 12, 1936 (July 6, 1934).

General

Adhesive properties of sodium-silicate solutions. ALBERT DEBECQ. *Verre & Silicates Ind.*, **7** [7] 78–79 (1936).—Sodium silicate does not spoil and is odorless, colorless, and noninflammable. Experiments show that a neutral liquid silicate with 38 to 40° Bé in which the ratio SiO_2:Na_2O = 3 to 3.5, that is, as much silica as possible, should be used. Determination of viscosity and fluidity is briefly dealt with. M.V.C.

Campaign against dangerous rock dusts in the Westphalian-Rhine coal mines. ANON. *Zentr. Gewerbehyg. Unfallverhüt.*, **22**, 88–94 (May-June, 1935).—Tests made by the Miners Occupational Insurance Assn. for dust-prevention in boring operations at the Bochum (Germany) mines are recorded. From 1930 to 1933, 1433 coal miners died of dust diseases, principally silicosis. On Jan. 1, 1934, 2104 coal miners were being compensated for severe silicosis; 1433 miners' widows and 1057 dependents were receiving pensions. The insurance association, which carries the Reich Insurance under the Ordinance of 1929 (and subsequent enlarged or better-defined sections) for occupational diseases, inaugurated a campaign for dust prevention to avoid further waste and loss of man power. A

foam appliance is described for dust control, especially in boring operations with pneumatic tools and for disposal of dust accumulations in mine pits. The patent, Minimax-A.-G. F. Schurmayer, also covers new adaptations, increasing its usefulness according to tests. The use of foam as means of dust control in boring was first officially recognized in 1928. Subsequent stages of its application and mechanical development are given. A detailed description of the apparatus and 6 illustrations are included. The foam apparatus acts at the hammer, absorbing the dust in its viscid, soapy streams at the point of dust origin. These streams are under pressure according to rock hardness and other boring requirements. They also swirl in on the floor dusts, as these when dried might be dangerous, being easily thrown into the air again. Dust control in these same mines requires the wet spray, as not all places bored into allow the use of foam appliances. Rinsing fluids are applied in a similar manner. Details of these operations are given. K.R.

Ceramic manufacture in Australia. E. T. McPhee. *Official Yearbook Commonwealth Australia*, **28**, 794–812 (1935).—In 1934, there were 408 factories making brick, pottery, glass, etc.; of these, 183 were in New South Wales, and 104 in Victoria. Persons employed numbered 9020; 92 were children under 16 years of age. Salaries to staff and overseers amounted to £225,686 for males and £17,131 for females; wages to workers, £1,233,046 for males and £19,942 for females; total £1,495,805. Power, fuel, and light cost £522,836; raw materials, £927,231. Land and buildings were valued at £2,374,697, plants and machinery at £2,414,175. The value of output was £4,022,761. H.H.S.

Ceramics making the headlines. Herbert V. Kaeppel. *Ind. Marketing*, **21** [5] 26 (1936).—The position of the ceramic industry after six years of depression is discussed; in the porcelain enamel industry, manufacturers of household equipment are exceeding pre-depression volume. H.S.

Ceramics in the telephone. A. G. Johnson and L. I. Shaw. *Ind. Eng. Chem.*, **27** [11] 1326–32 (1935).—The general distribution of the use of electrical porcelain, vitreous enameled parts, glass, and heavy clay products in the telephone system is discussed. The requirements which these products must meet for satisfactory functioning, their advantages and disadvantages, and a brief description of miscellaneous methods and some problems of manufacture are given. Illustrated. F.G.H.

Employment of ceramic graduates. Anon. *Bull. Amer. Ceram. Soc.*, **15** [5] 193 (1936).

Fluid ounce, U. S. and British. Anon. *H. M. Board of Trade Ann. Rept.* (1934); abstracted in *Analyst*, **61**, 41–42 (Jan., 1936).—The U. S. fluid ounce = $^1/_{128}$ of the U. S. gallon, which is 231 cu. in. The Imperial fluid ounce = $^1/_{160}$ of the Imperial gallon, which is 277.42 cu. in. The U. S. fluid ounce is therefore 1.041 times the Imperial fluid ounce. H.H.S.

Microbiology of aging clays. Dudley P. Glick. *Jour. Amer. Ceram. Soc.*, **19** [6] 169–75 (1936); see *Ceram. Abs.*, **14** [10] 260 (1935).

Pottery, its history and technique. Henry P. McIlhenny. *Bull. Amer. Ceram. Soc.*, **15** [5] 195–97 (1936).

Pottery industry in Shek-Waan, Kwangtung. Hoh Shai-Kwong. *Lingnan Sci. Jour.* [Supplement], **12**, 57–64 (1933).—The pottery industry of today in Shek-Waan, Kwangtung, is still primitive and closely resembles the procedure followed many years ago. Two grades of clay are used in the body, the Yi Shun, a gray and plastic clay, and the Ko-Liu, a red clay. The use of these clays depends upon the article to be made, and blends of the two are often used. The ware produced is mainly tile, pipes, cooking and garden ware, and decorative articles, all once fired. The firing is done in a peculiar type of kiln, which is located on a hill and slopes at an angle of from 15 to 20°. The kiln itself is a tube-like structure, 200 ft. long, 3 ft. wide, and 3 ft. high on the inside at the bottom, gradually getting larger until at the top it is 6 ft. wide and 7 ft. high. The brick walls are about 8 in. thick. At intervals about 30 inches apart along the top are transverse rows of fuel holes about 2 in. in size. Wood is used in firing the kiln. A fire is first built in the lower end of the kiln, and the smoke and hot gases are drawn up through the kiln, preheating the ware throughout the rest of the kiln. As the bottom approaches the finishing temperature (1200°C), the fireman moves up to the next set of fire holes and adds more wood until that section has reached its finishing temperature; this procedure is repeated until the entire kiln has been fired off. M.C.S.

BOOK AND BULLETIN

Building and Public Works laboratories in Paris. (Laboratoires du batiment et des travaux publics). *L'Entreprise Française* [Special No.], **5** [59] 284 pp. (Nov., 1935). Price 50 F. This special number contains full particulars of the Building and Public Works Laboratories, 12 rue Brancion, Paris, opened in June, 1935. The laboratories offer modern and precise means for studying the mechanical strength of building materials, their composition, and physical and chemical properties. The following articles are included: (1) speeches delivered at the dedication; (2) constructional features by R. Patouillard-Demoriane; (3) history of laboratory tests by Anstett; (4) modern methods for physical and mechanical study of solid materials by R. L'Hermite; (5) soil research laboratory and foundation work by Armand Mayer; (6) work of the chemical laboratory in the building and public works industries by Lafuma; (7) water-tightness by F. Pernant; and (8) how to make use of the services of the laboratory: (*a*) preliminary tests, (*b*) tables, (*c*) list of tests. Illustrated. M.V.Condoide

Operating costs of light-duty trucks. Anon. Published by the Policyholders Service Bur., Metropolitan Life Insurance Co., New York. 37 pp. Free. Special studies of truck-operating costs have been conducted by the Bureau. Vehicles with a rated capacity of $1^1/_2$ tons or less come under the category of light-duty equipment. Information concerning the cost of operating these trucks and certain additional statistics that furnish some measurement of the performance secured under certain conditions are presented. Bureau publications on "Controlling costs and operation of business automobiles," "Cost of operating two-ton trucks," and "Operating costs of heavy duty trucks" are also available without charge. Henry H. Smith

PATENTS

Process and means for the exfoliation of vermiculite. HONEYWILL & STEIN, LTD., AND G. C. WRIGHT. Brit. 446,045, May 6, 1936 (June 5, 1935).

Roofing granule and process of making. E. A. LEONARD (Orenda Corp.). U. S. 2,037,802, April 21, 1936 (Dec. 30, 1933). A flat granule formed of fired clay artificially colored throughout the granule has a shape similar to a slate granule in that its top and bottom surfaces are substantially parallel, the thickness of the granule between the surfaces being less than its length along the surfaces.

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